Estimates of fish, spill, and juvenile fish bypass passage efficiencies of radio-tagged juvenile salmonids relative to spring and summer spill treatments at John Day Dam in 2002

Final Report of Research during 2002

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Summary

Spring

From 29 April through 04 June 2002, 602 wild juvenile steelhead and 1,569 hatchery origin yearling Chinook salmon were radio-tagged and released 23 km above John Day Dam (JDA) to compare the effects of 0% day spill and 60% night spill (12 h treatment) to 30% day spill and 30% night spill (24 h treatment) on fish passage.

- No significant differences in non-turbine passage (fish passage efficiency; FPE) of juvenile steelhead or yearling Chinook salmon were found between treatments when diel periods were pooled. Significant differences were found in proportions of both species passing via the spillway (SPE) and juvenile bypass system (JBYPE) when diel periods were pooled (Summary Table 1).

- There was no significant treatment difference in steelhead FPE at nioght, but, there were significant differences in both SPE and JBYPE (Summary Table 1). No statistical comparisons of steelhead passage during the day were made, because few steelhead passed during this period.

- FPE, SPE and JBYPE differed significantly for yearling Chinook salmon during both the day and night. The treatments resulted significant changes in passage via the spillway and juvenile bypass, however, the changes offset each other and resulted in no overall significant difference in FPE (Summary Table 1).

Summer

From 24 June to 25 July 2002, 2,881 subyearling Chinook salmon of hatchery origin were radio-tagged and released 23 km above JDA to compare the effects of 0% day spill and 60% night spill (12-h treatment) to 30% day spill and 30% night spill (24-h treatment) on fish passage behavior.

- No significant difference in overall subyearling Chinook salmon FPE during the pooled diel periods was detected between treatments, but passage via the spillway was significantly lower, and passage via the juvenile bypass was significantly greater, during the 12-h than the 24-h treatment (Summary Table 2).

- Diel estimates for FPE and spillway passage differed significantly between 12- and 24-h treatments for both diel periods. There were significant treatment effects in JBYPE during the day, but not at night (Summary Table 2).

Summary Table 1. Passage estimates (Est) of juvenile steelhead and yearling Chinook salmon during 12- and 24-h spill treatments at John Day Dam, spring 2002. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass efficiency. *N* = sample size. LRCI = likelihood ratio confidence interval.

Steelhead

Diel	Passage	12 h			24 h		
Period	Metric	Est	95% LCRI	*N*	Est	95% LCRI	*N*
Pooled	FPE	91.0	86.9-94.1	334	88.4	83.1-92.6	334
	SPE	64.2	53.4-74.1	334	54.3	41.5-66.8	334
	JBYPE	26.8	17.1-38.2	334	34.1	21.7-48.3	334
Day	FPE	-	-	-	-	-	-
	SPE	-	-	-	-	-	-
	JBYPE	-	-	-	-	-	-
Night	FPE	93.2	89.8-96.7	207	89.0	83.5-94.4	127
	SPE	73.9	63.2-83.0	207	45.7	31.7-60.1	127
	JBYPE	19.3	10.6-30.7	207	43.3	28.0-59.6	127

Yearling Chinook

Diel	Passage	12 h			24 h		
Period	Metric	Est	95% LCRI	*N*	Est	95% LCRI	*N*
Pooled	FPE	84.7	81.7-87.4	613	82.4	79.2-85.3	605
	SPE	48.3	43.2-53.4	613	56.7	51.6-61.7	605
	JBYPE	36.4	30.1-42.0	613	25.7	20.9-31.0	605
Day	FPE	73.5	67.3-79.1	215	92.0	88.6-94.7	301
	SPE	N/A	N/A	215	73.1	67.9-77.9	301
	JBYPE	73.0	65.1-80.1	215	18.9	13.8-25.0	301
Night	FPE	90.7	87.6-93.3	398	73.4	68.2-78.1	304
	SPE	74.1	68.0-79.7	398	40.8	33.4-48.5	304
	JBYPE	16.6	12.3-21.6	398	32.6	26.1-39.5	304

Summary Table 2. Passage estimates (Est) of subyearling Chinook salmon during 12- and 24-h spill treatments at John Day Dam, summer 2002. FPE = fish passage efficiency. SPE = spill passage efficiency. JBYPE = juvenile bypass efficiency. *N* = sample size. LRCI = likelihood ratio confidence interval.

Subyearling Chinook							
Diel	Passage	12 h			24 h		
Period	Metric	Est	95% LCRI	*N*	Est	95% LCRI	*N*
Pooled	FPE	71.8	67.8-75.6	500	70.4	66.6-74.1	571
	SPE	41.6	34.6-48.9	500	57.8	51.0-64.4	571
	JBYPE	30.2	26.3-34.3	500	12.6	10.1-15.5	571
Day	FPE	54.6	47.8-61.4	205	79.5	74.6-83.9	288
	SPE	N/A	N/A	205	66.0	66.0-66.0	288
	JBYPE	54.6	47.8-61.4	205	13.5	9.9-17.8	288
Night	FPE	83.7	77.9-88.6	295	61.1	53.7-68.2	283
	SPE	70.5	61.6-78.5	295	49.5	40.1-58.9	283
	JBYPE	13.2	8.0-20.0	295	11.7	6.7-18.3	283

Introduction

A Supplemental Biological Opinion issued by the National Marine Fisheries Service (NMFS, now NOAA Fisheries) recommended that spill volumes at dams on the Columbia and Snake rivers be maximized to increase juvenile salmonid (*Oncorhynchus* spp.) survival without exceeding the current total dissolved gas (TDG) cap levels or other project-specific limitations (NMFS 1998). At John Day Dam (JDA), completion of spillway flow deflectors has increased the potential for greater spill volumes at this project while remaining under the TDG cap. Thus, the NMFS recommended that 24 h spill studies should be initiated at JDA in 1999 as a means of enhancing fish passage efficiency relative to the night-only spill mandated in the current Biological Opinion (NMFS 1998). At JDA, juvenile salmonids pass the dam via non-turbine routes through either the spillway, or the juvenile-fish-bypass system (JBS) after being diverted from turbine passage by submerged traveling screens.

Studies of 24 h spill at JDA began in 1999 and were continued in 2000 and 2002. The dam operations studies in 1999 were a 12 h spill treatment of 0% day spill and 45% night spill versus a 24 h spill treatment of 30% day spill and 45% night spill and in 2000 the conditions were similar, but the night spill was 53% (see review by Anglea et al. 2001). The design in each of these years called for 60% night spill, but it was not achieved. The general results indicated that non-turbine passage was not significantly different between treatments except for subyearling Chinook salmon in 2000, when it was greater during the 24 h treatment (Hansel et al. 2000a, 2000b, Beeman et al. 2003). Regional fishery managers requested evaluations of 0% day spill and 60% night spill against a 24 h treatment of 30% spill in 2002 based on previous results and the lack of spill for the 60% design in 1999 and 2000.

In 2002, the U.S. Army Corps of Engineers (COE) contracted with the U.S. Geological Survey to determine the passage efficiency, spill effectiveness, and forebay residence times of juvenile salmonids at John Day Dam. Our specific objectives were to:

1) estimate fish passage efficiency (FPE), spill passage efficiency (SPE) and spill effectiveness of radio-tagged wild juvenile steelhead (*O. mykiss*) and yearling and subyearling Chinook salmon (*O. tshawytscha*) passing JDA under 12 and 24 h spill scenarios, and 2) estimate forebay residence times of radio-tagged juvenile salmonids passing at JDA. The study was divided into spring (wild juvenile steelhead and yearling Chinook salmon migration) and summer (subyearling Chinook salmon migration) periods.

Methods

Study Site

John Day Dam is located on the Columbia River at river km 347 (Figure 1). The dam consists of a single powerhouse of 16 installed turbine units and facilities for 4 additional units between the existing units and the spillway (skeleton bays), and a single spillway of 20 tainter gates. The nameplate capacity is 2,160 megawatts. Both powerhouse and spillway are perpendicular to river flow. A navigation lock is located at the northwest end of the dam.

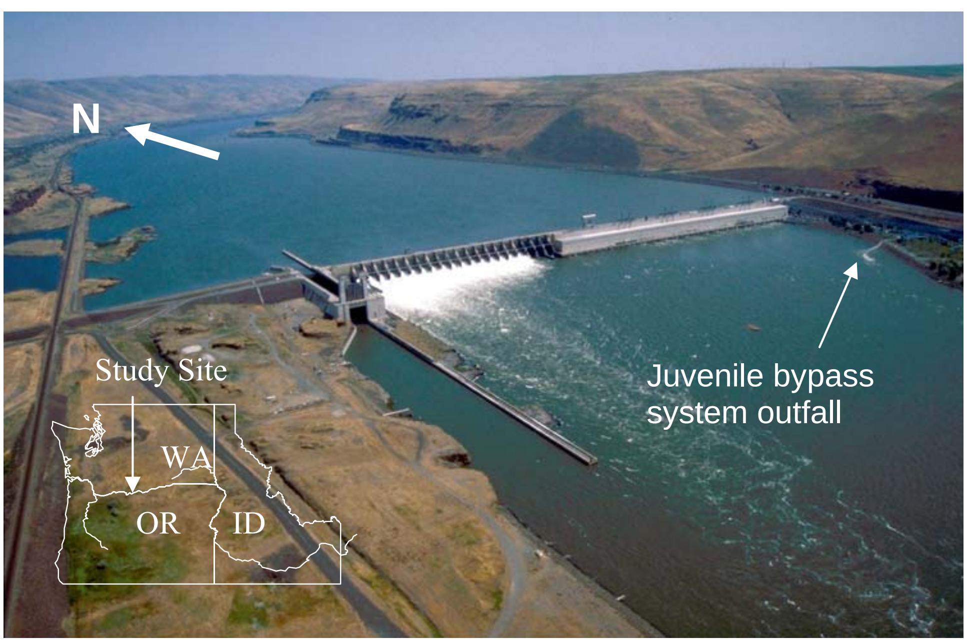

Figure 1. Photo John Day Dam at Columbia River km 347.

Dam Operations

The study design was based on a 2-d period of 12 h spill followed by a 2-d period of 24 h spill. The planned 12 h spill condition had no daytime spill (0600 to 1859 hours) and 60% of the total discharge passed as spill at night (1900 to 0559 hours). The planned 24 h spill condition was 30% of the total discharge passed via the spillway during both day and night. Treatments were alternated using a randomized block design and began on 29 April 2002 and ended on 25 July 2002 for a total of seven 4-d study time periods during the spring and four 4-d time periods in the summer (Appendix A). These 4-d time periods will hereafter be referred to as blocks. Hourly powerhouse and spillway discharge data were obtained from the COE and compiled by the USGS for each study period. Our study results are based on analyses of blocks identified by the U.S. Army Corps of Engineers to have met the study objectives based on discharge and spill percentage. As a result, we analyzed blocks 6 through 12 for the spring period and blocks 24 through 27 for the summer period.

Telemetry Receiving Equipment

Radio receiving systems using aerial and underwater antennas were used to detect radio-tagged fish near JDA. Ten 4-element Yagi (aerial) antennas were positioned along the forebay side of the powerhouse and spillway to detect fish within about 100 m of the dam face, defined as the near-dam area. Each aerial antenna in the forebay monitored an area in front of a pair of turbine units or spill bays; four aerial antennas were also mounted along the navigation lock wall to monitor fish movements near the lock and north end of the spillway. Aerial antennas were connected to SRX-400 receivers (Lotek Wireless, Inc., Newmarket, Ontario, Canada[1]), which recorded telemetry data, following the methods of Hensleigh et al. (1999). An additional ten aerial antennas were used to monitor the tailrace sides of the turbines and spillway. The SRX-400 receivers in the forebay were configured to scan all antennas combined (master antenna) until a signal was received, and then cycle through individual aerial antennas (auxiliary antennas) to

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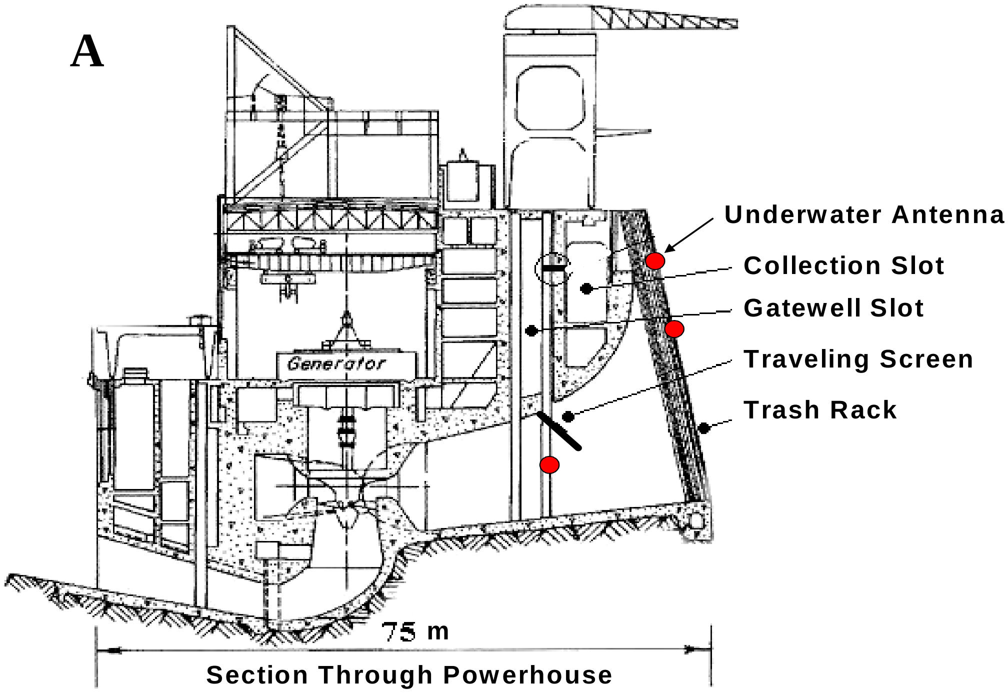
[1] Reference to trade names does not imply endorsement.

determine a more precise location of the transmitter. The inputs from tailrace aerial antennas were combined to provide resolution only to north and south sides of the spillway and turbines to reduce scan time due to the short time fish spend near the tailrace side of the dam relative to the forebay. Aerial antennas were also mounted near the JBS outfall, on the dredge island near the tailrace boat-restricted zone, and on both riverbanks about 5.3 km downstream from the dam. Underwater dipole antennas were used to monitor radio-tagged juvenile salmonids within about 10 m of each turbine unit or spillway tainter gate, and stripped coax antennas (coaxial cables with the distal 23 cm of shielding removed) were used within the juvenile fish bypass system (Beeman et al. 2004). Underwater dipole antennas at the turbines were placed at elevations 247 ft above mean sea level (MSL) and 227 ft MSL (approximately 18 ft and 28 ft deep at normal pool elevation 265 ft MSL). They were located in the center of the "B" slot above the trash racks of each turbine unit and on the lower support beam of the traveling screen in each intake slot (Figure 2A). At the spillway, four underwater dipole antennas were used to monitor passage at each spill bay. Two antennas were installed along each of the two pier noses encompassing each spill bay at elevations 227 and 247 ft MSL (as at the turbines); each antenna was pointed toward the center of the spill bay (Figure 2B). Inputs from all underwater antennas were monitored by a single Multiprotocol Integrated Telemetry Acquisition System (MITAS; Grant Systems Engineering, King City, Ontario, Canada). The MITAS system is a PC-based monitoring system. Two additional underwater antennas were installed in the JBS near its entrance to the smolt monitoring sample facility and near the outfall to determine if tagged fish were shunted into the sample facility; a Lotek Wireless DSP-500 digital spectrum processor and SRX-400 combination monitored these antennas.



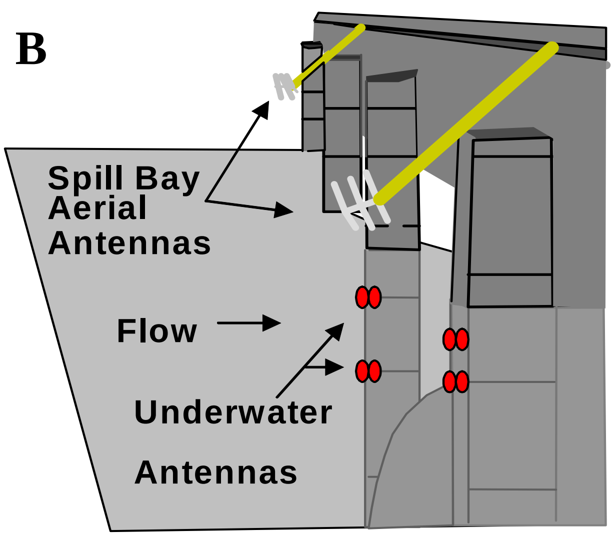


Figure 2. Location of underwater antennas (filled circles) in the middle of the B slot of turbine units 1 through 16 and below the traveling screens in the A, B, and C slots of each unit (A), and the location of aerial and underwater antennas on spill bay pier noses (B) at John Day Dam, 2002.

Fish Tagging, Handling and Release

This study was based on radio-tagged juvenile wild steelhead, yearling and subyearling Chinook salmon of primarily hatchery origin released as part of several concurrent studies at JDA. The studies were designed to determine FPE, tailrace egress times, and project survival. Tagged fish used in this study were released in the Columbia River near at Rock Creek, 23 km upstream from JDA. Releases occurred at 0900 hours and 2100 hours. Juvenile steelhead and yearling Chinook salmon to be implanted with radio transmitters were obtained through the Smolt Monitoring Program operated by the Pacific States Marine Fisheries Commission at JDA. Fish to be implanted were typically held at the collection facility for 12 to 24 h prior to tagging. Fish were considered suitable for tagging if they were free of major injuries, severe descaling, external signs of gas bubble trauma, or other obvious abnormalities.

Pulse-coded transmitters operating at frequencies between 150.320 and 150.760 MHz were used to allow individual fish to be recognized. Two sizes of transmitters were used to accommodate the different sizes of spring and summer migrants. Transmitters implanted in juvenile steelhead and yearling Chinook salmon were 7.3 mm in diameter x 18.0 mm in length and weighed 1.4 g in air (Lotek Wireless model MCFT-3KM) and those implanted in subyearling Chinook salmon were 6.3 mm x 4.5 mm x 14.5 mm long and weighed 0.85 g in air (Lotek Wireless model NTC-3-1). Both transmitter types had a flexible 30-cm antenna. Transmitters were gastrically implanted using the methods of Martinelli et al. (1998).

Following tagging, fish were held in tanks at the juvenile bypass collection facility for 20 to 28 h to allow fish time to recover from the procedure. After the holding period, the tanks were checked for mortalities and fish were transported either to Rock Creek and released into the northern area of the Columbia River or were released through the spillway, juvenile bypass, or directly into the tailrace of JDA. Regurgitated tags were removed from the containers immediately prior to release when present.

Data Management and Analysis

Data from radiotelemetry receivers and the MITAS system were downloaded every other day and imported into applications based on SAS software for subsequent proofing and analyses. These data were manually proofed to eliminate non-valid records including background noise, single records of a particular channel and code, records that were collected prior to the known release date and time, and records indicating that the fish eaten by avian or piscine predators. Generally, the minimum amount of data required to validate the presence of a radio-tagged fish was a combination of two master antenna and one auxiliary antenna detections or three master antenna detections within 1 to 2 min of each other.

The location and time an individual fish was first detected by telemetry receivers on the dam face was considered the route and time of entrance into the near-dam area. Similarly, the location and time of the last detection of an individual fish on the receivers on the dam face was considered the route and time of passage through the dam. However, radio-tagged fish were often detected on multiple auxiliary antennas where zones of coverage overlapped, making data reduction necessary. Fish detected on more than one auxiliary antenna within a two-minute period at the time of passage were assigned to a single passage location corresponding to the antenna where the highest strength signal was recorded and all other records were excluded. A two-minute interval was chosen because it approximately coincided with the upper boundary of time needed to complete a scan cycle if several fish were present at any given time. Manual tracking on the dams has verified that the last detection by telemetry receiving stations is typically a good estimate of the passage route (Sheer et al. 1997; Holmberg et al. 1998; Hensleigh et al. 1999).

Fish passage efficiency (FPE) was determined as the proportion of the total number of radio-tagged fish exiting the near-dam JDA forebay that passed via non-turbine routes (i.e., through the spillway or the juvenile bypass system) multiplied by 100%.

$$FPE = \frac{(\text{fish last detected at spillway} + \text{fish last detected at JBS}) * 100\%}{\text{fish last detected at spillway} + \text{fish last detected at JBS} + \text{fish last detected at turbines}} \quad \text{Equation 1}$$

Similarly, spill passage efficiency (SPE) and juvenile bypass efficiency (JBYPE) were calculated as the proportion of the total number of radio-tagged fish that passed through the spillway or sluiceway, respectively, multiplied by 100%.

$$SPE = \frac{\text{fish last detected at spillway} * 100\%}{\text{fish last detected at spillway} + \text{fish last detected at JBS} + \text{fish last detected at turbines}} \quad \text{Equation 2}$$

$$JBYPE = \frac{\text{fish last detected at the juvenile bypass system} * 100\%}{\text{fish last detected at spillway} + \text{fish last detected at JBS} + \text{fish last detected at turbines}} \quad \text{Equation 3}$$

Raw numbers of fish detected passing the turbines, spillway, and juvenile bypass system were adjusted by the detection probabilities of the telemetry arrays at each route of passage prior to reporting and statistical analysis using Equations 4, 5 and 6. The detection efficiencies of the telemetry arrays at the turbines, spillway, and juvenile bypass system were calculated using a “double array” system as described by Lowther and Skalski (1997). This method is based on the number of fish detected and undetected at each of two arrays to determine the detection probability of each array, and ultimately, the combination of the two arrays. In a double-array system, the detection probability of one array is calculated as:

$$P1 = 11/(11+01) \quad \text{Equation 4}$$

where 11 denotes fish that were detected on both arrays and 01 denotes those not detected on the first array, but detected on the second. The detection probability of the second array is calculated as:

$$P2 = 11/(11+10) \quad \text{Equation 5}$$

where 10 denotes those detected on the first array, but not the second. The overall detection probability of the combined arrays is calculated as:

$$P12 = 1-((1-P1)*(1-P2)) \qquad \text{Equation 6}$$

The numbers of fish detected at each array are then adjusted by dividing the numbers detected at an array by the results of Equation 6 prior to calculation of the passage indices (e.g., FPE). Thus, the adjusted FPE would be calculated as:

$$FPE_{adj} = ((sp\# / P12_{spillway}) + (jbs\# / P12_{bypass}))/ ((ph\# / P12_{turbines}) + (sp\# / P12_{spillway}) + (jbs\# / P12_{bypass})) \qquad \text{Equation 7}$$

where sp#, jbs# and ph# are the numbers of fish detected passing the spillway, juvenile bypass system, and turbines, respectively. For the purpose of this exercise, the forebay aerial and underwater arrays at the turbines and spillway were each considered as a single upstream array (*P1*) for that route of passage and the aerial antennas in the tailrace of each area were considered the downstream arrays (*P2*). The upstream and downstream arrays in the JBS each consisted of several stripped coaxial cables combined into a single inputs located at the upstream end of the primary dewaterer (*P*1) and in the JBS flume immediately downstream from the primary dewaterer (*P*2).
Spill effectiveness was calculated as a ratio of the percent of fish passed via the spillway (SPE) to the percentage of total river flow being spilled.

Statistical analyses comparing the passage indices calculated for each treatment, block, and day (0600 to 1859 hours) and night (1900 to 0559 hours) time periods were completed using logistic regression after adjusting for differences in blocks. Logistic regression estimates the probability of an event (e.g., passing via a non-turbine route) after converting the dependent variable to a logit (the natural log of the event occurring or not). An "odds ratio" is calculated from the odds of the dependent variable occurring in each of the two classes (i.e., day and night passage), and from this, the relative importance of the independent variables in terms of the effects on the dependent variable is estimated (similar to a beta weight in a least-squares regression). For example, if the hypothetical odds ratio between day and night FPE is 5, the probability of passing via a non-turbine route during the day is 5 times greater than at night. Overdispersion was assessed within each species by examining the models' residual deviance divided by residual degrees of freedom. Ninety-five percent profile likelihood confidence intervals were calculated for the overall odds ratio.

Residence time in the near-dam area, defined as the amount of time between the first and last detections in the forebay, was calculated for each radio-tagged fish detected in the near-dam forebay area (residence times were not calculated for fish detected only at entrance and exit stations). These residence times are minimum estimates of the actual time that radio-tagged fish spent in the near-dam area due to the chance that a fish might have been in the near-dam area for an unknown amount of time prior to their first detection and following their last detection.

Diel approach and passage patterns among blocks were compared graphically. Diel residence times within species were compared controlling for block effects using Friedman's Chi-square test. Results of this test and others throughout this report were considered statistically significant when $P \leq 0.05$.

Results from the Spring Study Period

Dam Operations

The mean hourly percent spill discharge at JDA during the spring was similar to the 12 and 24 h spill proposed during the design phase of the study (Table 1). During the 12 h spill condition, daytime spill ranged from 0% to 7% with a mean of 0.3%. At night, the spill ranged from 28% to 63% with a mean of 55%. During the 24 h-spill condition, daytime spill ranged from 25% to 32% with a mean of 29%. At night, the spill ranged from 14% to 32% with a mean of 29%. Mean project discharge ranged from 136 to 340 thousand cubic feet per second (KCFS) during the study. Total discharge at the beginning of the study period was below the 10-year average, but increased during most of the study period and was greater than the 10-year average prior to declining during the last block of study (Figure 3). Water temperature increased throughout the study period, and had an average of 12.2 C (range 9.8 to 14.5 C). Forebay elevation varied little, with an average of 263.3 ft and range between 263.1 and 263.6 ft (Figure 4).

Table 1. Mean hourly percentages of total discharge spilled and mean hourly total discharge (KCFS) at John Day Dam during seven 4 d blocks, 30 April through 28 May 2002. Proposed spill treatments consisted of one 2 d treatment of no day spill discharge (0600 – 1759 hours) and 60% night discharge (1800 - 0559 hours; 12 h treatment) followed by a 2 d treatment of 30% day spill discharge and 30% night discharge.

		Hourly percent spill					
	Spill	0600-1759			1800-0559		
Block	treatment	Mean	Std	Range	Mean	Std	Range
6	12 h	0.6	1.6	0-7.1	45.8	10.9	28.1-59.3
	24 h	29.4	1.2	25.4-30.4	29.7	0.8	27.7-31.3
7	12 h	0.6	1.9	0-7.3	55.2	4.0	44.1-61.1
	24 h	30.1	0.6	29.1-32.0	29.6	0.6	28.2-30.9
8	12 h	0.5	1.2	0-4.6	53.9	5.2	43.7-59.9
	24 h	29.5	0.4	28.7-30.3	29.7	0.7	28.0-30.9
9	12 h	0.1	0.6	0-2.7	58.8	1.8	54.0-62.6
	24 h	29.3	0.8	27.8-31.0	29.7	3.6	13.6-32.4
10	12 h	0.2	0.8	0-4.3	58.6	1.6	54.0-60.4
	24 h	29.5	0.3	28.8-30.3	29.7	0.3	29.2-30.4
11	12 h	0.2	0.9	0-4.3	55.0	4.1	44.6-61.2
	24 h	29.1	0.8	27.5-30.5	29.3	1.1	25.3-30.2
12	12 h	0.2	0.8	0-4.0	57.7	3.2	51.6-61.4
	24 h	29.6	0.7	28.5-31.2	28.0	1.9	25.3-30.1

		Hourly total discharge					
	Spill	0600-1759			1800-0559		
Block	treatment	Mean	Std	Range	Mean	Std	Range
6	12 h	207.8	51.4	136.7-294.7	245.8	25.4	200.7-298.7
	24 h	222.7	15.6	198.0-257.9	223.6	32.4	156.4-291.8
7	12 h	218.7	28.4	169.9-273.0	264.0	31.5	207.5-340.2
	24 h	210.8	26.2	152.4-247.8	234.3	41.8	154.6-286.0
8	12 h	216.4	34.7	171.9-280.6	224.5	26.1	176.7-274.3
	24 h	192.0	22.2	168.3-234.0	220.2	28.2	183.3-289.2
9	12 h	220.4	25.4	185.4-266.2	201.7	34.0	163.4-262.1
	24 h	194.2	45.0	142.0-276.6	177.7	26.2	140.4-233.9
10	12 h	196.9	17.5	177.2-244.1	240.7	21.4	199.6-276.3
	24 h	197.3	25.0	166.0-237.2	215.0	22.9	183.9-255.9
11	12 h	260.9	10.0	248.5-278.1	279.4	22.0	234.5-310.6
	24 h	247.8	22.9	214.3-280.6	268.9	21.7	240.8-322.0
12	12 h	258.5	21.2	225.3-286.5	261.4	24.2	204.2-300.3
	24 h	242.2	19.4	215.3-282.8	251.6	38.5	210.6-300.4

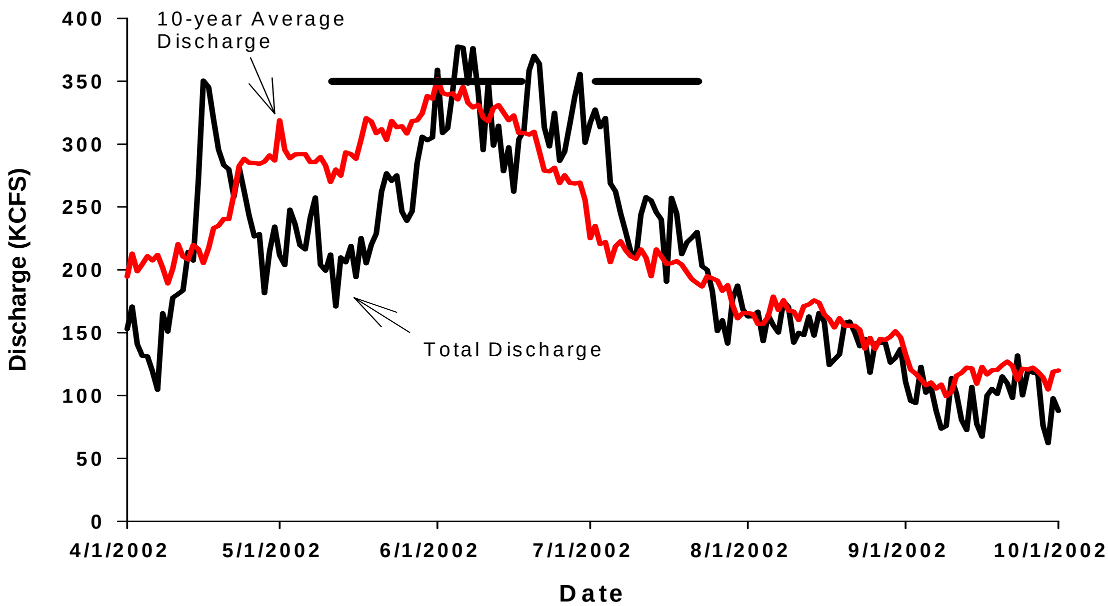


Figure 3. Total discharge (2002) and 10-year average (1992-2002) of total discharge for John Day Dam. Horizontal bars indicate spring and summer release periods. Data from University of Washington at http://www.cqs.washington.edu/dart/river.html.

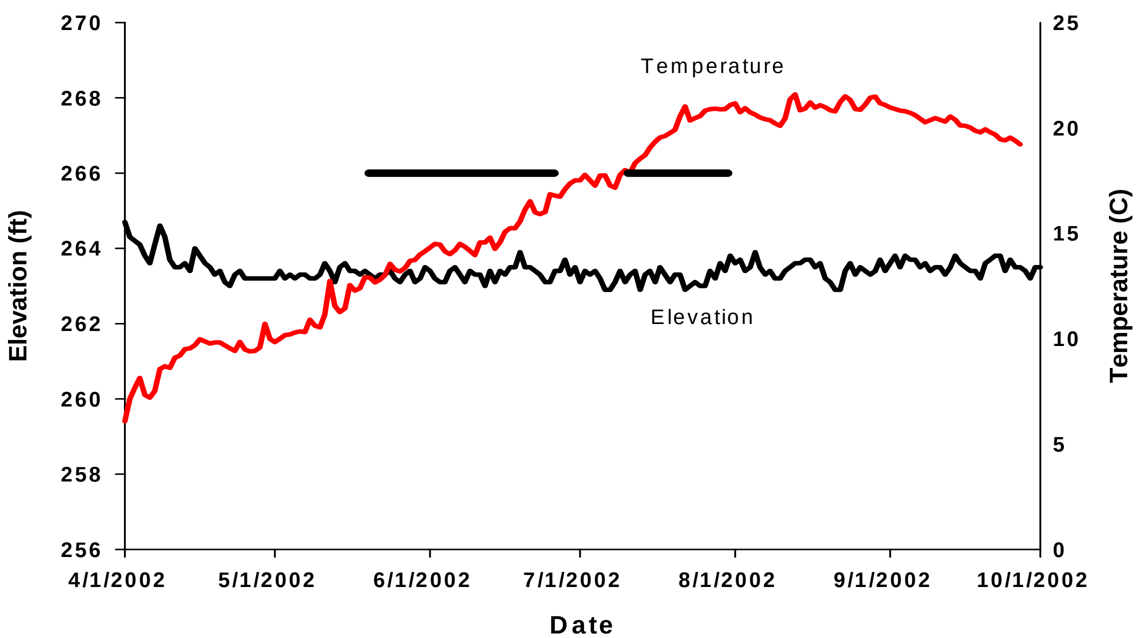


Figure 4. Elevation and water temperature at John Day Dam forebay between 01 April and 01 October 2002. Horizontal bars indicate spring and summer release periods. Data from University of Washington at http://www.cqs.washington.edu/dart/river.html.

Number of Fish Released and Detected

From 29 April through 04 June 2002, 602 wild juvenile steelhead and 1,569 yearling Chinook salmon were radio-tagged and released at Rock Creek. Fish were released from between the 21.9 and 77.4 percentile of wild juvenile steelhead passage and the 7.8 and 84.3 percentile of passage of yearling Chinook salmon at John Day Dam (Figure 5). Juvenile steelhead from all releases combined had a mean fork length of 190 mm (range 143 to 275 mm) and a mean weight of 64 g (range 24 to 202 g). Yearling Chinook salmon from all releases combined had a mean fork length of 148 mm (range 116 to 205 mm) and a mean weight of 33 g (range 16 to 85 g). Fish sampled by the Smolt Monitoring Program during our study period averaged 198 mm in length (range 118 to 390 mm) for juvenile steelhead and 147 mm (range 97 to 245 mm) for yearling Chinook salmon. The mean tag-weight to body-weight ratios of radio-tagged juvenile steelhead and yearling Chinook salmon were 2.2 % (range 0.01 to 5.8%) and 4.2% (range 0.02 to 8.7%), respectively. Telemetry equipment at the dam detected 92% of the juvenile steelhead released and 91% of the yearling Chinook salmon released. Summaries of juvenile steelhead and yearling Chinook salmon releases are in Appendices B and C.

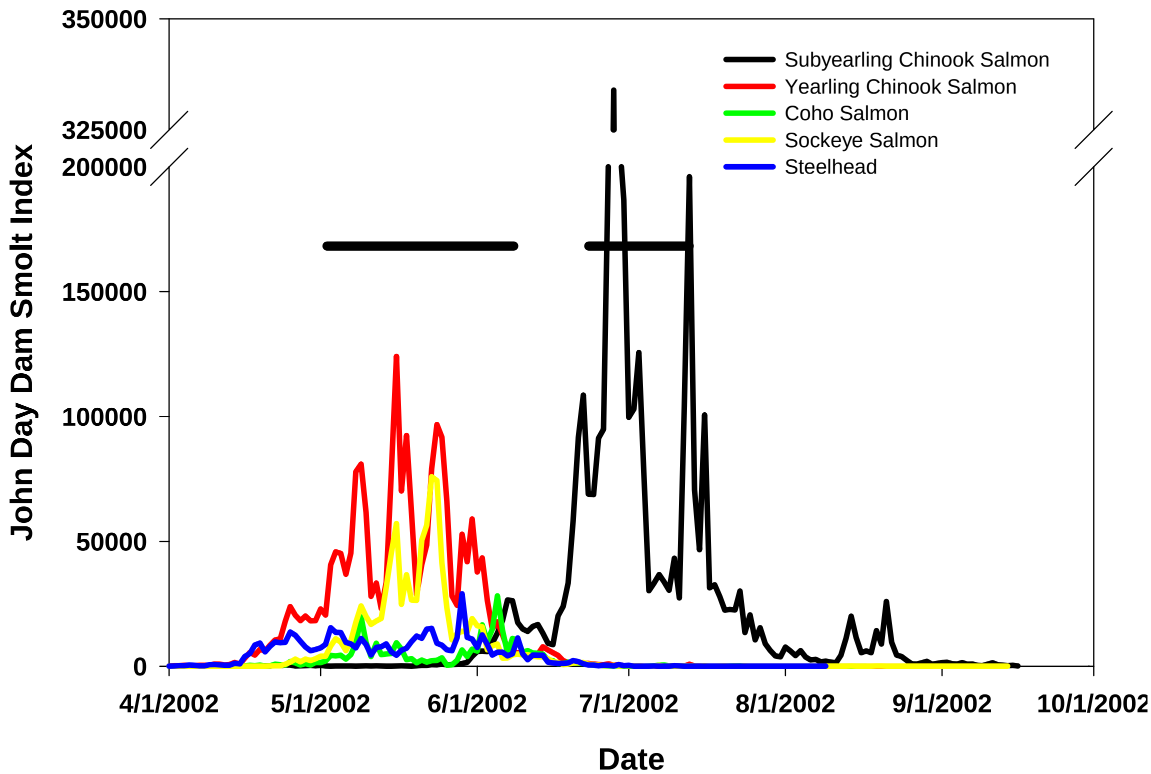


Figure 5. Smolt passage index at John Day Dam between 01 April and 01 October 2002. Horizontal bars indicate spring and summer release periods. Data from University of Washington website at http://www.cqs.washington.edu/dart/river.html.

Detection Probabilities by Route

Detection probabilities were high for all passage routes and were similar among routes. Detection probabilities of juvenile steelhead at the spillway and JBS were greater than 0.98 regardless of diel period or treatment and those at the turbines ranged from 0.89 to 1.00 (Table 2). Detection probabilities of yearling Chinook salmon at the spillway and JBS were greater than 0.98 regardless of diel period or treatment and those at the turbines ranged from 0.96 to 1.00.

Table 2. Juvenile steelhead and yearling Chinook salmon diel capture histories and detection probabilities at telemetry arrays at the John Day Dam turbines, spillway, and juvenile fish bypass system during spring 2002. Capture history “10” = number of fish detected only on array 1, “01” = number of fish detected only on telemetry array 2, and “11” = number of fish detected on both array 1 and 2. P1 = probability of detection on array 1. P2 = probability of detection on array 2. P12 = probability of detection for array 1 and 2 combined.

Juvenile Steelhead

	Day						Night					
Capture History	Turbines		Spillway		Juvenile Bypass		Turbines		Spillway		Juvenile Bypass	
	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h
01	1	0	0	1	1	0	2	0	2	0	0	0
10	3	5	1	1	8	1	5	3	10	5	20	22
11	4	1	2	34	16	3	6	11	141	53	20	33
Total	8	6	3	36	25	4	13	14	153	58	40	55
	Detection Probabilities											
P1	0.80	1.00	1.00	0.97	0.94	1.00	0.75	1.00	0.99	1.00	1.00	1.00
P2	0.57	0.17	0.67	0.97	0.67	0.75	0.55	0.79	0.93	0.91	0.50	0.60
P12	0.91	1.00	1.00	1.00	0.98	1.00	0.89	1.00	1.00	1.00	1.00	1.00

Yearling Chinook Salmon

	Day						Night					
Capture History	Turbines		Spillway		Juvenile Bypass		Turbines		Spillway		Juvenile Bypass	
	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h
01	0	0	0	3	0	0	3	7	4	1	1	1
10	20	6	0	15	59	22	11	14	34	15	28	51
11	37	18	1	202	98	35	23	60	257	108	37	47
Total	57	24	1	220	157	57	37	81	295	124	66	99
	Detection Probabilities											
P1	1.00	1.00	1.00	0.99	1.00	1.00	0.88	0.90	0.98	0.99	0.97	0.98
P2	0.65	0.75	1.00	0.93	0.62	0.61	0.68	0.81	0.89	0.88	0.57	0.48
P12	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.98	1.00	1.00	0.99	0.99

Travel Time, Arrival Time, and Approach Pattern

Juvenile steelhead and yearling Chinook salmon median travel times from the Rock Creek release site to the near-dam forebay were 28.8 h and 18.0 h, respectively. The median travel time of juvenile steelhead released at 0900 hours was 26.4 h (range 10.8 to 146.4 h) and the median travel time of fish released at 2100 hours was 30.0 h (range 12.0 to 103.2 h). The median travel time of yearling Chinook salmon was 18.0 h for both day (range 8.4 to 135.6 h) and night (range 9.6 to 189.6 h) releases. The hour of arrival at JDA was dispersed throughout the diel period, though the number of fish arriving peaked near 0400 hours for juvenile steelhead and 0100 hours for yearling Chinook salmon (Figure 6).

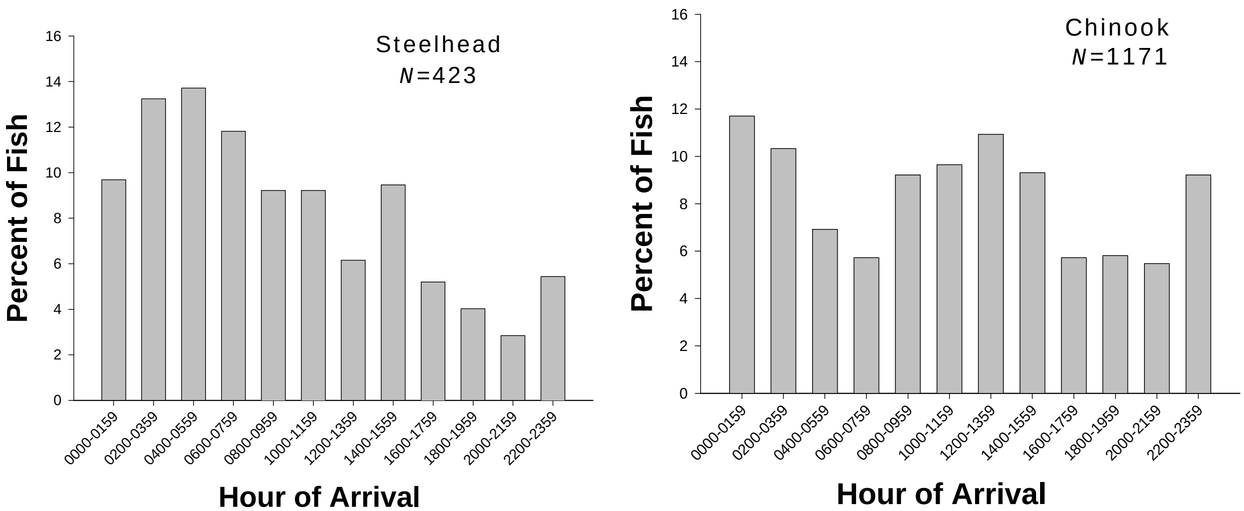


Figure 6. Hour of arrival (2 h intervals) of radio-tagged juvenile steelhead and yearling Chinook salmon within about 100 m of John Day Dam, 30 April through 28 May 2002.

Locations of first detections differed between treatments and between diel periods, and the trends were similar during most of the study period. The area of approach of juvenile steelhead within about 100 m of the dam, the approximate range of aerial antennas on the dam, was generally similar between the two treatments during the day and night, but at night more fish first approached near the spillway than during the day (Figure 7). First detections of juvenile steelhead within about 10 m of the dam, the approximate range of underwater antennas on the dam, were primarily near the powerhouse during the day and the spillway at night (Figure 8). The approach of yearling Chinook salmon within about 100 m of the dam was predominantly at the powerhouse during both treatments, but the proportions first detected at the powerhouse were greatest in the day during the 12 h treatment and at night during the 24 h treatment

(Figure 7). When they approached within about 10 m from the dam they were primarily at the powerhouse in the day during both treatments, but at night they were about evenly distributed between the powerhouse and spillway during the 12 h treatment and were present in a greater proportion at the powerhouse than the spillway during the 24 h treatment (Figure 8).

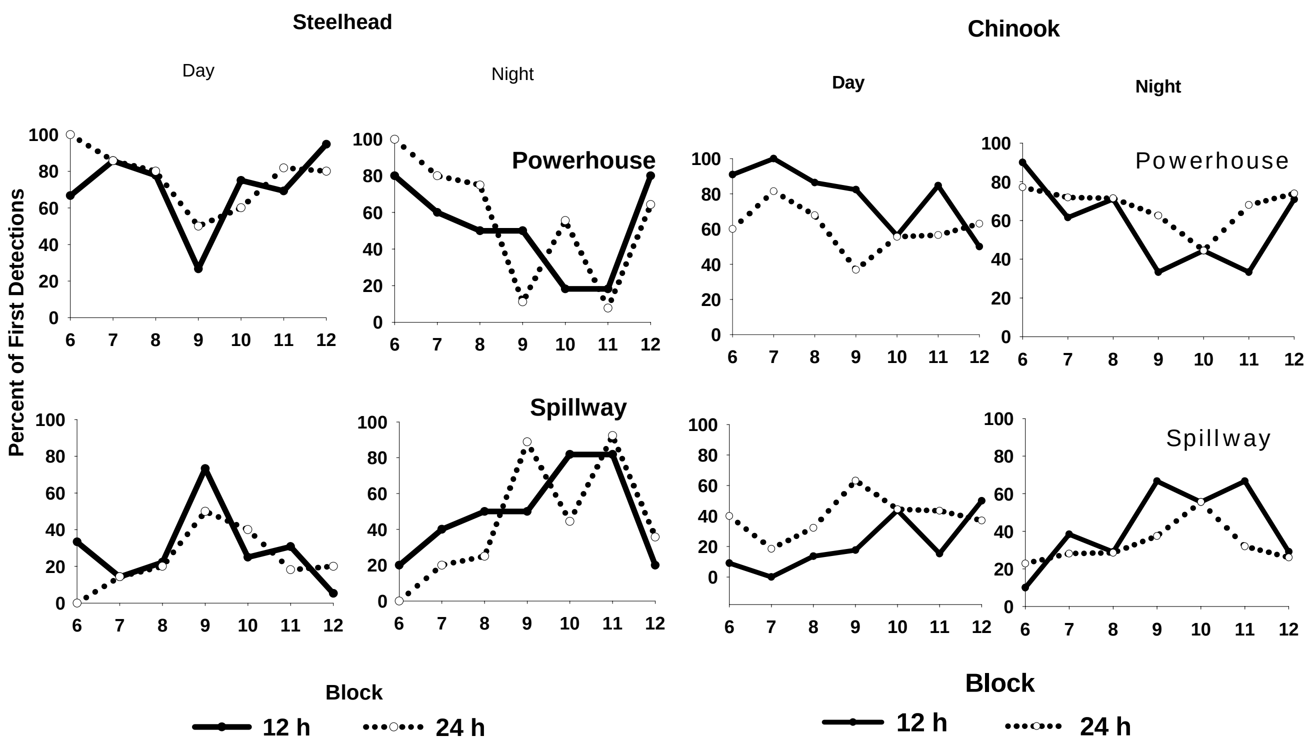


Figure 7. Percentage of radio-tagged juvenile steelhead and yearling Chinook salmon first detected within about 100 m of the powerhouse and spillway at John Day Dam during spring 2002.

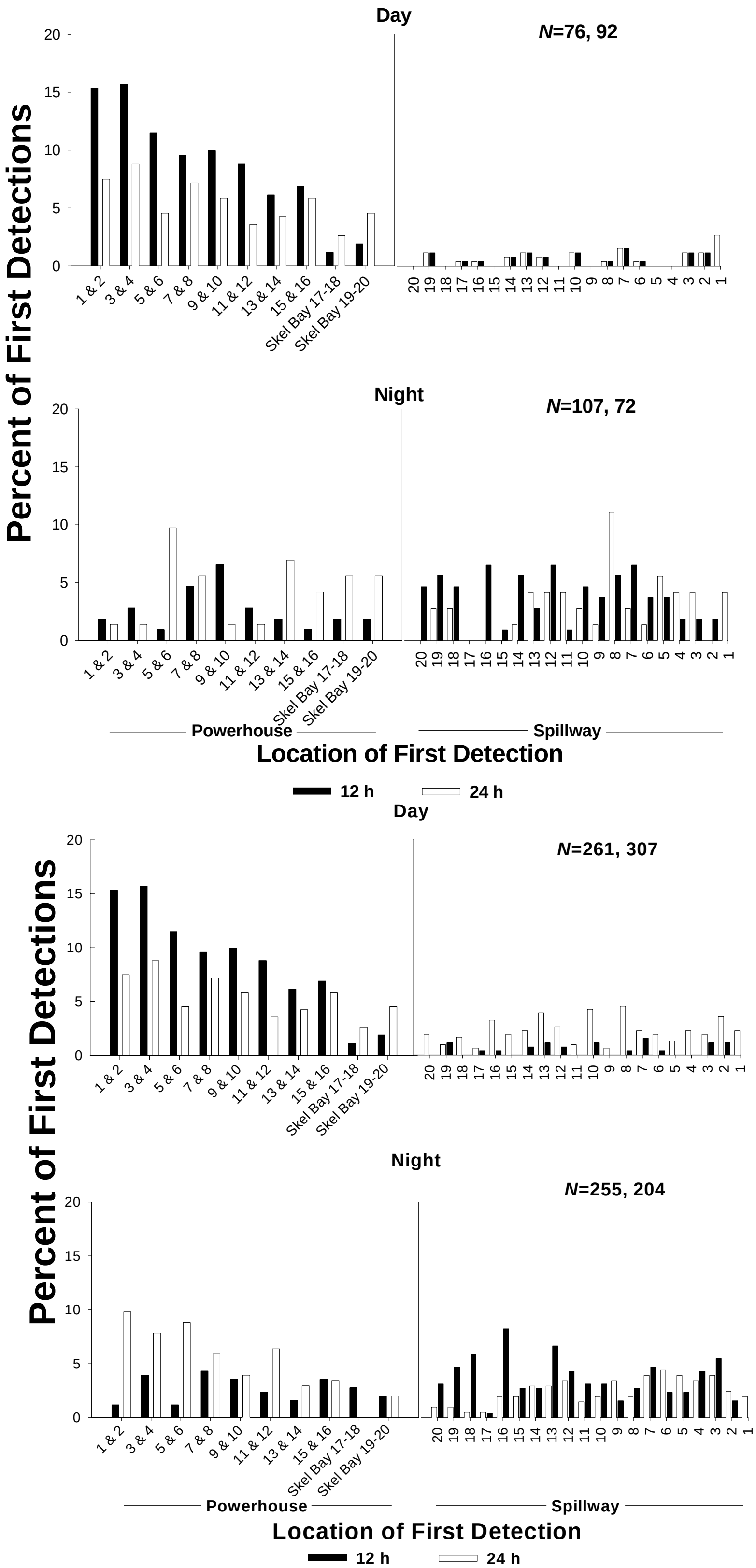


Figure 8. Percent of radio-tagged juvenile steelhead (upper 4 plates) and yearling Chinook salmon (lower 4 plates) first detected within about 10 m of John Day Dam during spring 2002. *N* = sample size (12 h, 24 h).

Forebay Residence Time

Median forebay residence times were influenced by the time of arrival (day vs. night) and the associated dam operations at JDA. Most juvenile steelhead arriving during the day passed during the night, resulting in long residence times of those arriving in the day (Table 3, Figure 9). The median forebay residence times of juvenile steelhead arriving during the day were 25 times longer than night arrivals during the 12 h treatment and 5 times longer that those arriving at night during the 24 h treatment. Yearling Chinook salmon arriving during the day also had longer residence times than that arriving at night, but the difference was not as large as in juvenile steelhead.

The differences in forebay residence times between day and night periods were statistically significant in most cases. This was the case in all test blocks of juvenile steelhead during the 12 h treatment and 2 out of 6 blocks during the 24 h treatment (Wilcoxon Rank Sum tests, Ps < 0.05, df = 1). The differences were also statistically significant in 5 out of 6 blocks of yearling Chinook salmon during the 12 h treatment and 1 out of 6 blocks during the 24 h treatment (Wilcoxon Rank Sum tests, Ps < 0.05, df = 1).

Forebay residence times did not differ between treatments within blocks during the day but there were some significant differences at night. Residence times of juvenile steelhead differed significantly between treatments in 2 out of 6 blocks at night and for yearling Chinook salmon they differed significantly in 3 out of 6 blocks at night (Wilcoxon Rank Sum tests, Ps < 0.05, df = 1).

Table 3. Twenty-fifth, 50th (median), and 75th percentiles of radio-tagged juvenile steelhead and yearling Chinook salmon forebay residence times (h) at John Day Dam by diel period and treatment (Trt) at arrival, 30 April through 28 May 2002. Residence times were calculated from first forebay time to last forebay time. Day and night refer to diel 12 h operating periods. 12 h treatment = 0% day spill and 60% night spill, 24 h treatment = 30% day spill and 30% night spill. *N* = sample size.

		Juvenile Steelhead				Yearling Chinook			
Diel Period	Trt	25th	Median	75th	N	25th	Median	75th	N
Day	12 h	6.2	13.1	33.6	112	0.4	2.1	7.1	280
	24 h	6.7	13.4	31.2	94	0.3	1.4	5.0	302
Night	12 h	0.3	0.5	3.6	115	0.1	0.5	2.6	307
	24 h	0.5	2.5	17.0	93	0.2	1.0	5.1	269

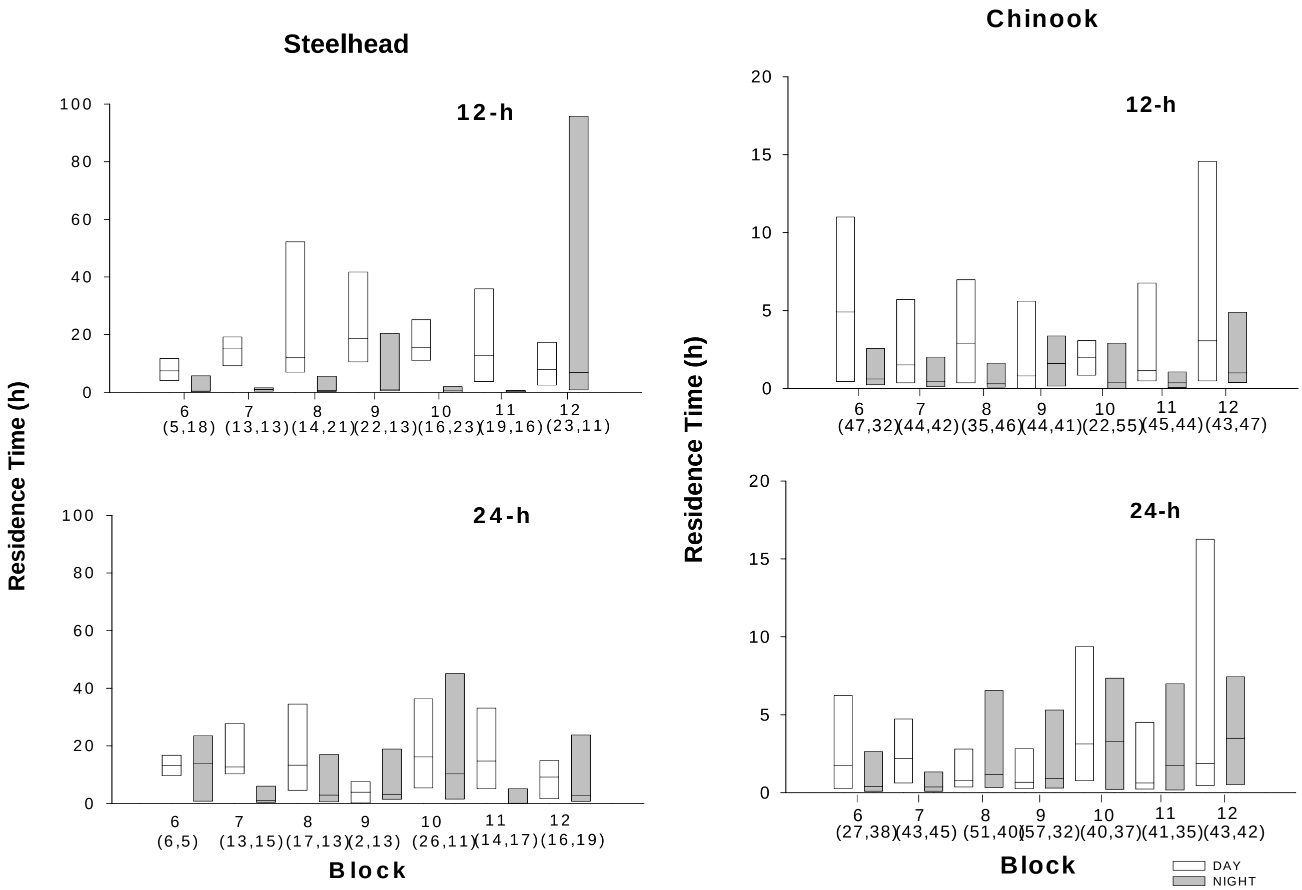


Figure 9. Twenty-fifth, 50th (median), and 75th percentiles (lower, middle, and upper horizontal lines on bars) of radio-tagged juvenile steelhead and yearling Chinook salmon forebay residence times by diel time of arrival at John Day Dam during spring 2002. Sample sizes are in parentheses (day, night). Note differences in scales between species.

Time and General Route of Passage

The passage of both species was chiefly at night, but this was much more pronounced in juvenile steelhead (Figure 10). Despite arrival times spread throughout the day and night, few juvenile steelhead passed the dam during the day: 14.9% (36 of 242) during the 12 h treatment and 26.6% (46 of 173) during the 24 h treatment. Their most prevalent passage routes during both treatments were the turbines during the day (when spill was absent) and the spillway at night (Figure 11). Yearling Chinook salmon day passage was greater than juvenile steelhead: 35.1% (215 of 613) during the 12 h treatment and 49.8% (301 of 605) during the 24 h treatment. The most prevalent passage route of yearling Chinook salmon was the turbines in the day during the 12 h treatment and the spillway during all other times.

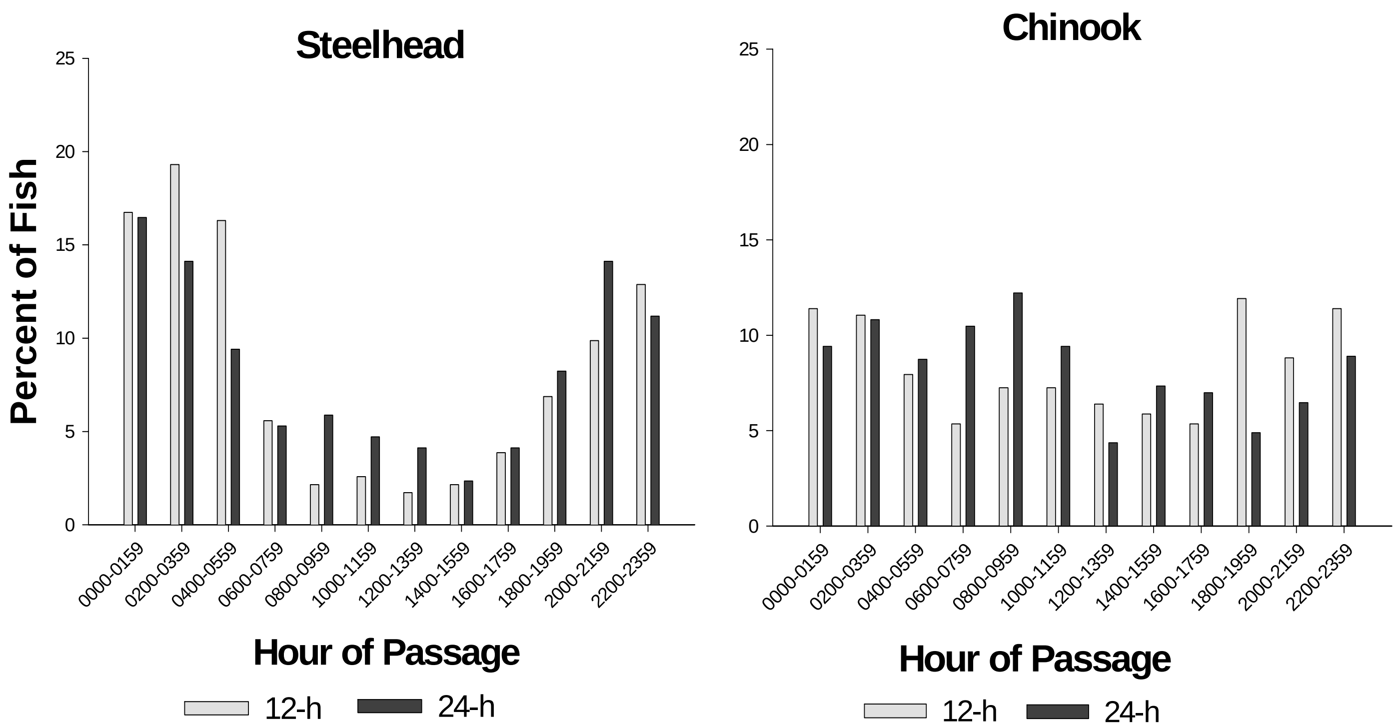


Figure 10. Hour of passage (2-h intervals) of radio-tagged juvenile steelhead and yearling Chinook salmon at John Day Dam during 12 and 24 h spill treatments from 30 April through 28 May 2002.

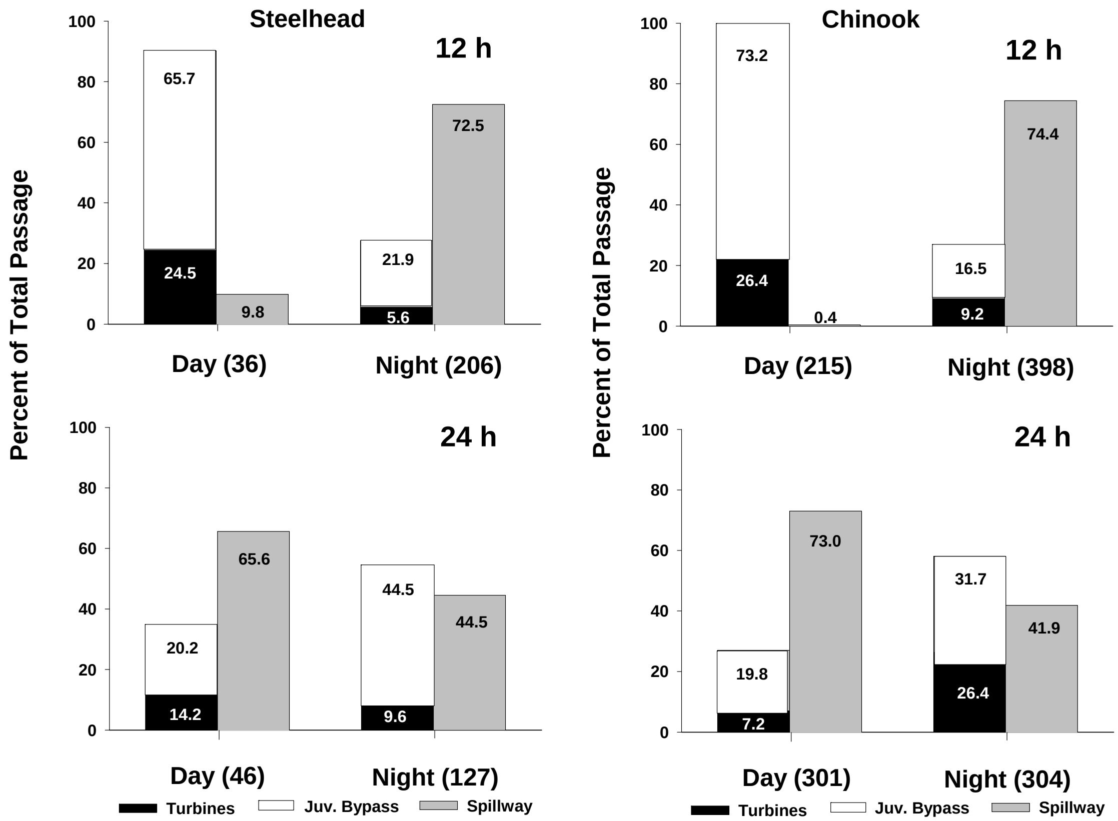


Figure 11. Radio-tagged juvenile steelhead and yearling Chinook salmon passage percentages via the turbines, juvenile fish bypass system (Juv. Bypass) and spillway at John Day Dam during 12 and 24 h spill treatments from 30 April through 28 May 2002. Sample sizes are in parentheses. Actual percent passage is on bars.

Fish, Spill, and Juvenile Fish Bypass Passage Efficiencies

The overall (diel periods pooled) FPE, SPE, and JBYPE of juvenile steelhead and yearling Chinook salmon were similar in each treatment and were generally consistent among blocks (Figure 12). The FPE of both species were lowest in blocks 10 and 11 during both treatments. The SPE and JBYPE of juvenile steelhead were quite variable during both treatments in blocks 6, 7, and 8 and the JBYPE of yearling Chinook salmon during the 24 h treatment in blocks 10 and 11 were lower than in the other blocks. The lack of steelhead passage during the day during each treatment precluded estimating their passage during the day. Numbers of fish passing the turbines, spillway, and juvenile bypass system by date, block, treatment, and diel period are in Appendices D and E.

When diel periods were pooled, no significant difference in overall FPE of juvenile steelhead (91 vs. 88%, $P = 0.41$) or yearling Chinook salmon (85 vs. 82%, $P = 0.28$) was detected between treatments (Table 4, Appendices F and G). There were, however, significant differences in SPE and JBYPE (diel periods pooled) between spill conditions for both species. The SPE of juvenile steelhead was significantly greater during the 12 h treatment (64 vs. 54%, $P = 0.0174$), and the SPE of yearling Chinook salmon was significantly greater during the 24 h treatment (57 vs. 48%, $P = 0.0037$, Appendices H and I). The JBYPE of juvenile steelhead was significantly greater during the 24 h treatment (34 vs. 27%, $P = 0.0441$) and that of the yearling Chinook salmon was significantly greater during the 12 h treatment (36 vs. 27%, $P < 0.0001$, Appendices J and K). The overall (diel periods pooled) FPE of both species was similar among blocks (Table 4, Figure 12). The SPE and JBYPE of yearling Chinook salmon was also similar among blocks, but those of juvenile steelhead were quite variable (Figure 12).

Table 4. Diel fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and JBYPE) estimates (Est) of juvenile steelhead and yearling Chinook salmon detected, spring 2002. *N*= sample size. LRCI= profile-likelihood confidence interval.

Steelhead

Passage		12 h			24 h		
Metric	Treatment	Est	95%LRCI	*N*	Est	95%LRCI	*N*
FPE	Day	-	-	-	-	-	-
	Night	93.2	89.8-96.7	207	89.0	83.5-94.4	127
	Overall	91.0	86.9-94.1	334	88.4	83.1-92.6	334
SPE	Day	-	-	-	-	-	-
	Night	73.9	63.2-83.0	207	45.7	31.7-60.1	127
	Overall	64.2	53.4-74.1	334	54.3	41.5-66.8	334
JBYPE	Day	-	-	-	-	-	-
	Night	19.3	10.6-30.7	207	43.3	28.0-59.6	127
	Overall	26.8	17.1-38.2	334	34.1	21.7-48.3	334

Yearling Chinook

Passage		12 h			24 h		
Metric	Treatment	Est	95%LRCI	*N*	Est	95%LRCI	*N*
FPE	Day	73.5	67.3-79.1	215	92.0	88.6-94.7	301
	Night	90.7	87.6-93.3	398	73.4	68.2-78.1	304
	Overall	84.7	81.7-87.4	613	82.4	79.2-85.3	605
SPE	Day	0.0	0.0	215	73.1	67.9-77.9	301
	Night	74.1	68.0-79.7	398	40.8	33.4-48.5	304
	Overall	48.3	43.2-53.4	613	56.7	51.6-61.7	605
JBYPE	Day	73.0	65.1-80.1	215	18.9	13.8-25.0	301
	Night	16.6	12.3-21.6	398	32.6	26.1-39.5	304
	Overall	36.4	30.1-42.0	613	25.7	20.9-31.0	605

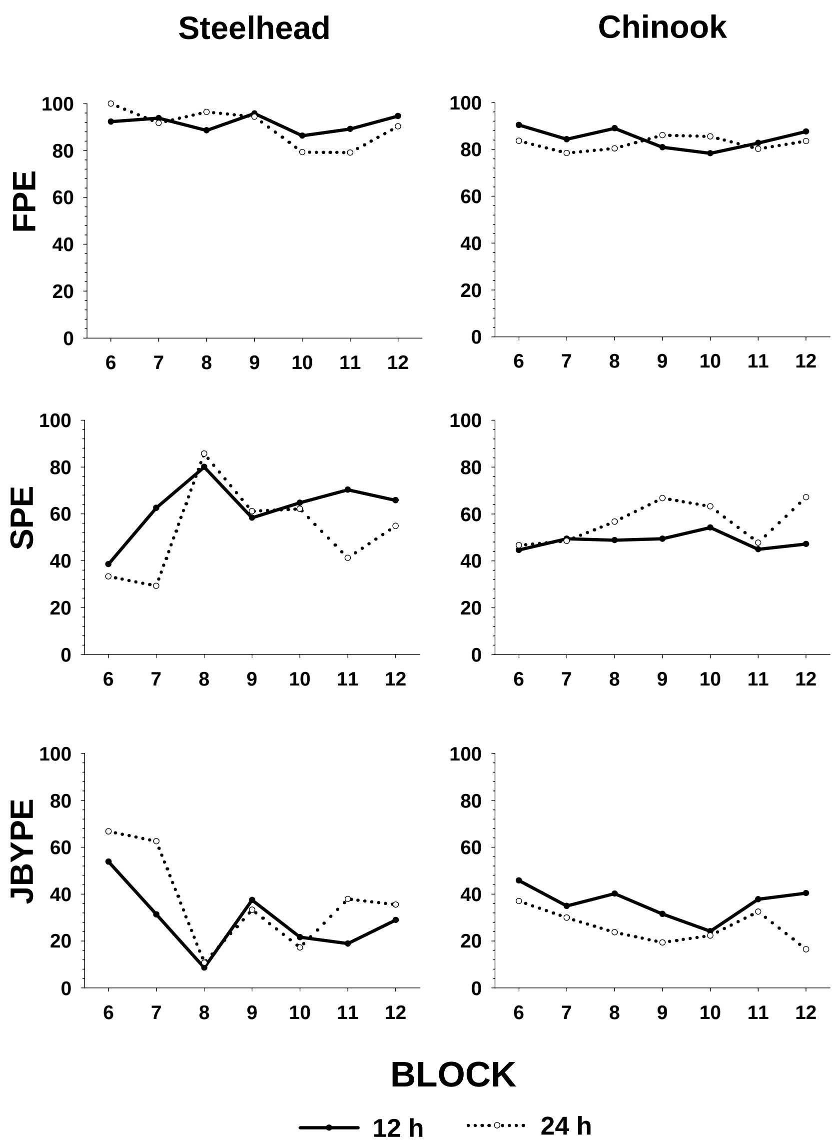


Figure 12. Overall fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile bypass passage efficiency (JBYPE) of juvenile steelhead and yearling Chinook salmon during spring 2002.

There were significant differences between treatments when passage efficiencies were analyzed by diel period. In general, significant differences in passage locations alternated between the spillway and juvenile bypass system depending on the level of spill; SPE was highest during periods of the greatest spill and JBYPE was greatest during the periods of least spill. Comparisons of passage metrics of juvenile steelhead were only done for the night period, because too few passed the dam during the day to make statistical inferences for that time period. Similarly, no comparisons of SPE between day and night were completed for the 12 h treatment, because there was little or no spill during the day. The FPE of juvenile steelhead passing at night was not significantly different between treatments (12 h 93.2%, 24 h 89.0%, $P = 0.1231$, Appendix L), but both SPE and JBYPE were significantly different between treatments at night. At night their SPE was greatest during the 12 h treatment (73.9 vs. 45.7%, $P = 0.0002$) and the JBYPE was greatest during the 24 h treatment (43.3 vs. 19.3%, $P < 0.0001$, Table 4, Appendices M and N). The FPE, and JBYPE of yearling Chinook salmon were significantly different between spill treatments during both day and night (Appendices O-Q). During the day, yearling Chinook salmon FPE was significantly greater during the 24 h treatment (92.0 vs. 73.5% $P < 0.0001$) and the JBYPE was significantly greater during the 12 h treatment (73.0 vs. 18.9% $P < 0.0001$). At night, their FPE and SPE were significantly greater during the 12 h treatment (FPE 90.7 vs. 73.4%, $P < 0.0001$; SPE 74.1 vs. 40.8% $P < 0.0001$) and the JBYPE was significantly greater during the 24 h treatment (32.6 vs. 16.6% $P < 0.0001$).

Spill Effectiveness

The spill effectiveness was greatest during the 24 h treatment in the day, followed by the 12 h treatment at night and the 24 h treatment at night (Table 5). Spill during the 24 h treatment, with equal spill percentages during day and night, was more effective during the day.

Table 5. Spill effectiveness of juvenile wild steelhead (Steelhead) and yearling Chinook salmon (Chinook) at John Day Dam in 2002. na = not applicable due to [1]little or no spill present or [2] low sample size.

Species	Treatment	Day	Night
Steelhead	12 h	na[1]	1.34
Steelhead	24 h	na[2]	1.55
Chinook	12 h	na[1]	1.35
Chinook	24 h	2.48	1.39

Results from the Summer Study Period

Dam Operations

The mean hourly percent spill discharge at JDA during the summer was similar to the proposed treatments: 12 h treatment of 0% day, 60% night and 24-treatment of 30% day and night (Table 6). During the 12 h treatment, daytime spill ranged from 0% to 11% with a mean of 0.4%. At night, the spill ranged from 45% to 62% with a mean of 58%. During the 24 h treatment daytime spill ranged from 24% to 41% with a mean of 29%. At night, the spill ranged from 27% to 32% with a mean of 30%. The mean project discharge ranged from 123 to 364 thousand cubic feet per second (KCFS) during the summer study period.

Total discharge at the beginning of the study period was below the 10-year average, but increased during most of the study period and was greater than the 10-year average prior to declining during the last block of study (Figure 3). Water temperature increased throughout the study period, and had an average of 19.7 C (range 17.9 to 21.0 C). Forebay elevation varied little, with an average of 263.2 ft and range between 262.9 and 263.5 ft (Figure 4).

Table 6. Mean hourly percent spill and mean hourly total discharge (thousand cubic ft per s, KCFS) at John Day Dam, 11 July through 27 July 2002. Proposed spill treatments consisted of one 2 d treatment of no day spill (0600 to 1959) and 60% night spill (2000 to 0559; 12 h treatment) and a second 2 d treatment of 30% day spill and 30% night spill (24 h treatment) randomized with four 4 d blocks. Std = standard deviation.

		Hourly Percent Spill					
		Day			Night		
Block	Spill Treatment	Mean	Std	Range	Mean	Std	Range
24	12 h	1	0	0-1	55	6	45-62
	24 h	30	3	26-41	30	1	28-32
25	12 h	1	3	0-11	59	2	55-61
	24 h	29	1	27-31	30	1	29-31
26	12 h	0	1	0-4	58	2	55-61
	24 h	29	2	24-31	30	1	29-31
27	12 h	0	1	0-5	59	2	56-62
	24 h	30	1	28-32	30	1	27-31

		Hourly Total Discharge (KCFS)					
		Day			Night		
Block	Spill Treatment	Mean	Std	Range	Mean	Std	Range
24	12 h	256	48	161-303	258	75	155-364
	24 h	247	35	189-325	255	29	208-308
25	12 h	220	35	164-286	202	32	157-265
	24 h	264	15	231-296	228	41	163-288
26	12 h	231	16	194-249	217	28	175-266
	24 h	233	31	168-274	209	38	156-276
27	12 h	211	19	162-250	182	32	149-244
	24 h	174	31	123-233	157	22	123-202

Number of Fish Released and Detected

A total of 2,881 subyearling Chinook salmon released at Rock Creek were used for this study. Releases were made at 0900 hours and 2100 hours each day between 24 June and 21 July and at 0900 hours only on July 22, 23, 24 and 25. Subyearling Chinook salmon from all releases combined had a mean fork length of 116 mm (range 110 to 153 mm) and a mean weight of 18 g (range 12 to 44 g). The mean fork length of all subyearling Chinook salmon sampled at the JDA Smolt Monitoring Program during the study period was 108 mm (range 71 to 165 mm). The mean tag-weight to body-weight ratio of tagged subyearling Chinook salmon was 4.7 % (range 1.9 to 7.1%). Telemetry equipment at the dam detected 81% of the radio-tagged subyearling Chinook salmon released. Summaries of each release are in Appendix R.

Detection Probabilities by Route

Detection probabilities were high for all passage routes and were similar among routes. Detection probabilities of subyearling Chinook salmon at the turbines, spillway and JBS were greater than 0.93 (range 0.93 to 1.00) during all diel periods and treatments (Table 7).

Table 7. Subyearling Chinook salmon diel capture histories and detection probabilities at the John Day Dam turbines, spillway, and juvenile fish bypass system (JBS), summer 2002. Capture history "10" = number of fish detected only on array 1, "01" = number of fish detected only on telemetry array 2, and "11" = number of fish detected on both arrays 1 and 2. P1 = probability of detection on array 1. P2 = probability of detection on array 2. P12 = probability of detection for array 1 and 2 combined.

	Day						Night					
Capture History	Turbines		Spillway		Juvenile Bypass		Turbines		Spillway		Juvenile Bypass	
	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h
01	8	4	0	2	3	4	6	14	5	2	0	3
10	26	20	0	9	46	12	7	11	31	6	21	12
11	56	32	0	179	61	20	35	82	172	132	18	16
Total	90	56	0	190	110	36	48	107	208	140	39	31
	Detection Probabilities											
P1	0.88	0.89	-	0.99	0.95	0.83	0.85	0.85	0.97	0.98	1.00	0.84
P2	0.68	0.62	-	0.95	0.57	0.63	0.83	0.88	0.85	0.96	0.46	0.57
P12	0.96	0.96	-	0.99	0.98	0.94	0.98	0.98	0.99	0.99	1.00	0.93

Travel Time, Arrival Time, and Approach Pattern

The median travel time of subyearling Chinook salmon from the Rock Creek release site to the JDA near-dam forebay (first detection via an aerial antenna) was 20.4 h. The median travel time of fish released at 0900 hours was 18.0 h (range 8.4 to 112.8 h) and the median travel time of fish released at 2100 hours was 25.2 h (range 10.8 to 160.8 h). The hour of arrival at JDA was dispersed throughout the diel period, although 44% of the subyearling Chinook salmon arrived between 1800 and 0200 hours (Figure 13).

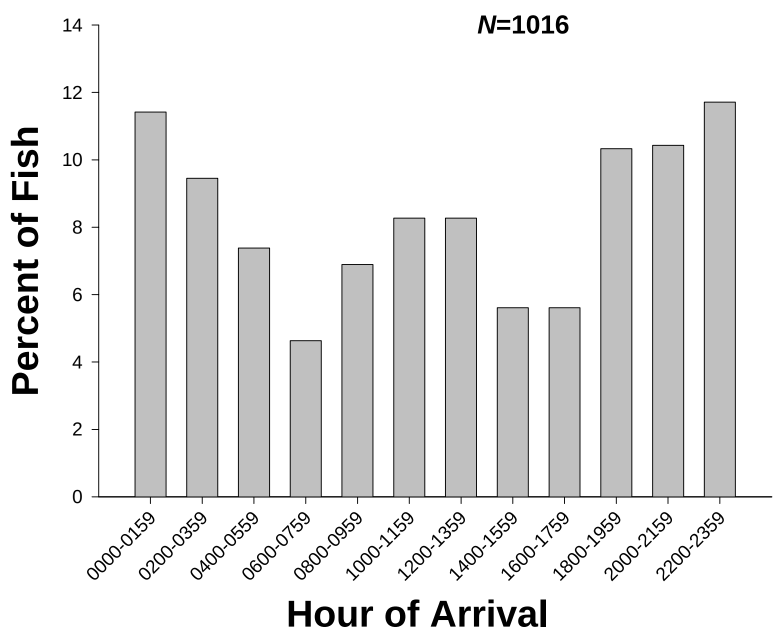


Figure 13. Hour of arrival (2-h intervals) of radio-tagged subyearling Chinook salmon within 100 m of John Day Dam, 11 July through 27 July 2002. All fish were released 23 km upriver of the dam near Rock Creek, Washington. *N* = sample size.

Locations of first detections of subyearling Chinook salmon differed between treatments. During the 12 h treatment, first detections within about 100 m of the dam were primarily at the turbines in the day (90%) and at the spillway at night (78%). During the 24 h treatment, first detections within about 100 m of the dam, the approximate range of the aerial antennas on the dam, were nearly equal during the day and night. These trends were generally similar among blocks (Figure 14). First detections within about 10 m of the dam, the approximate range of underwater antennas on the dam, were mostly at the turbines in the day and the spillway at night during the 12 h treatment, and were similar at the turbines and spillway during the 24 h treatment. These trends were similar in three of four time blocks (Figure 15).

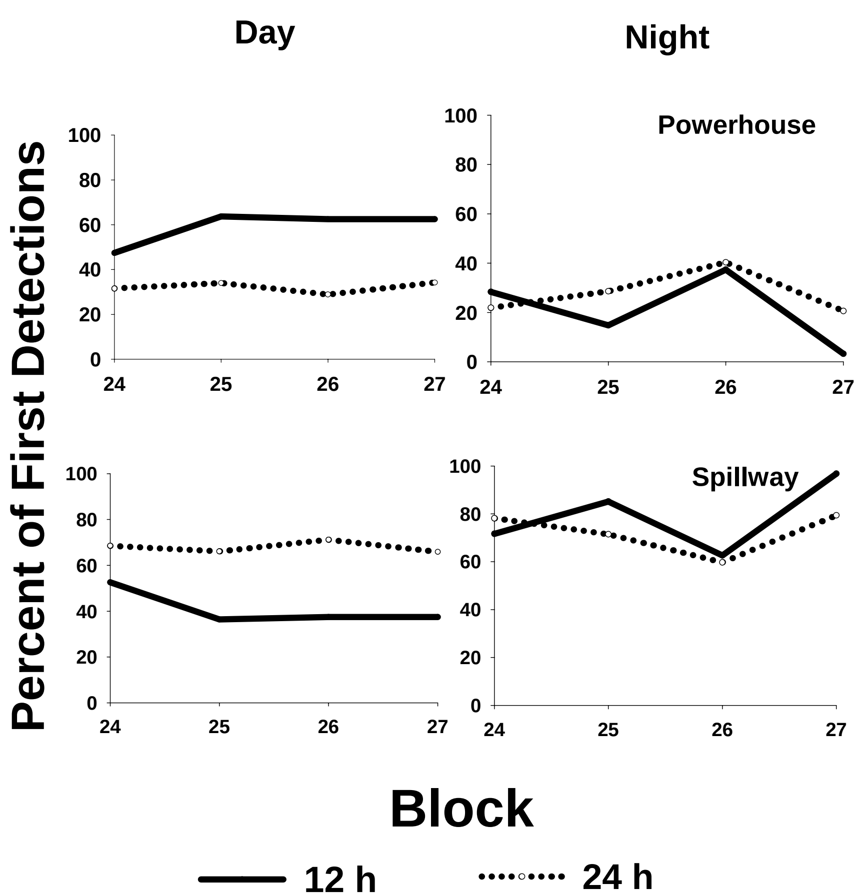


Figure 14. Percentage of radio-tagged subyearling Chinook salmon first detected by aerial antennas at the turbines and spillway during 12 and 24 h spill treatments at John Day Dam, 11 July through 27 July 2002. Blocks are 4 d intervals comprised of two 2 d treatments. Sample sizes for blocks ranged from 67 to 143 during the day and from 57 to 172 at night.

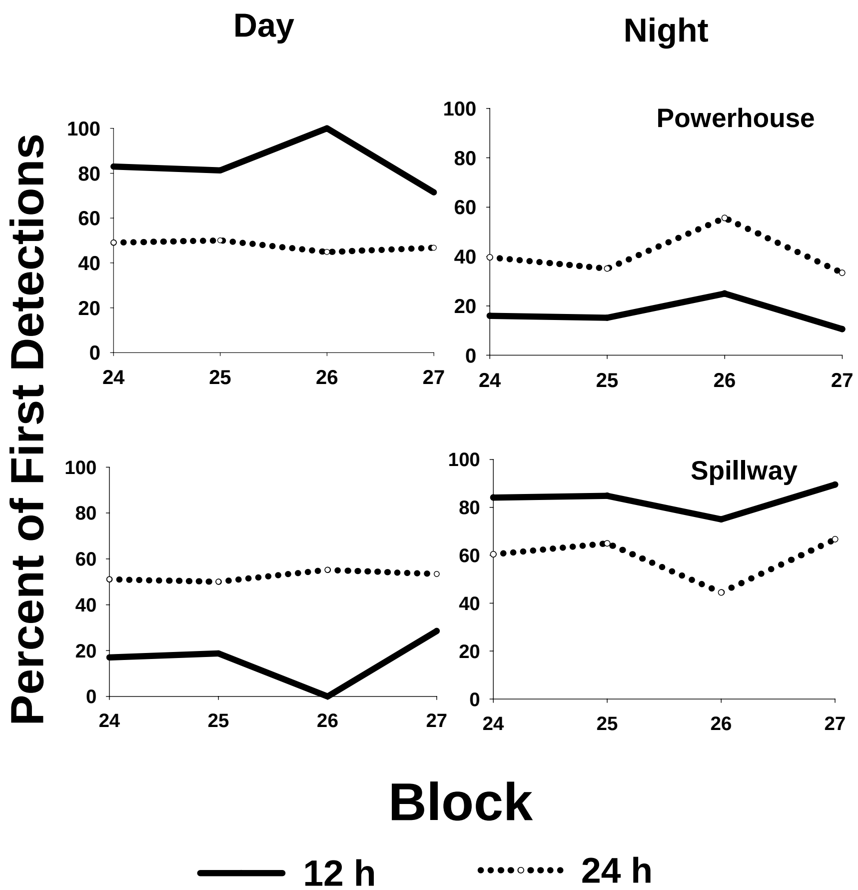


Figure 15. Percentage of radio-tagged subyearling Chinook salmon last detected by underwater antennas at the turbines and spillway during 12 and 24 h spill treatments at John Day Dam, 11 July through 27 July 2002. Blocks are 4 d intervals comprised of two 2 d treatments. Sample sizes for blocks ranged from 15 to 107 during the day and from 30 to 130 at night.

Forebay Residence Time

Median forebay residence times at JDA were influenced by the time of arrival (day vs. night) and the associated dam operations at JDA. Median forebay residence times of subyearling Chinook salmon were nearly the same for each diel period within a spill condition but differed significantly between treatments (Table 8). The median residence time was 0.3 h during the 12 h treatment during both day and night. During the 24 h treatment the median residence time was 1.0 h during both day and night.

Within blocks, forebay residence times were generally longer during the night than the day during both treatments, but this was more pronounced during the 12 h treatment (Figure 16). The differences in residence time between treatments were significant during both day and night in 3 of the 4 blocks (Wilcoxon Rank Sum tests, *P*s < 0.05, df = 1).

Table 8. Twenty-fifth, 50th (median), and 75th percentiles of radio-tagged subyearling Chinook salmon forebay residence time (h) at John Day Dam by diel period and treatment (Trt) at arrival, 11 July through 27 July 2002. Residence times were calculated from first forebay time to last forebay time. Day and night refer to diel 12 h operating periods. 012 h = 0% day spill and 60% night spill, 24 h = 30% day spill and 30% night spill. *N* = sample size.

Diel Period	Trt	25th	Median	75th	*N*
Day	12 h	0.0	0.3	2.0	191
	24 h	0.3	1.0	4.1	244
Night	12 h	0.0	0.3	1.1	298
	24 h	0.2	1.0	3.6	283

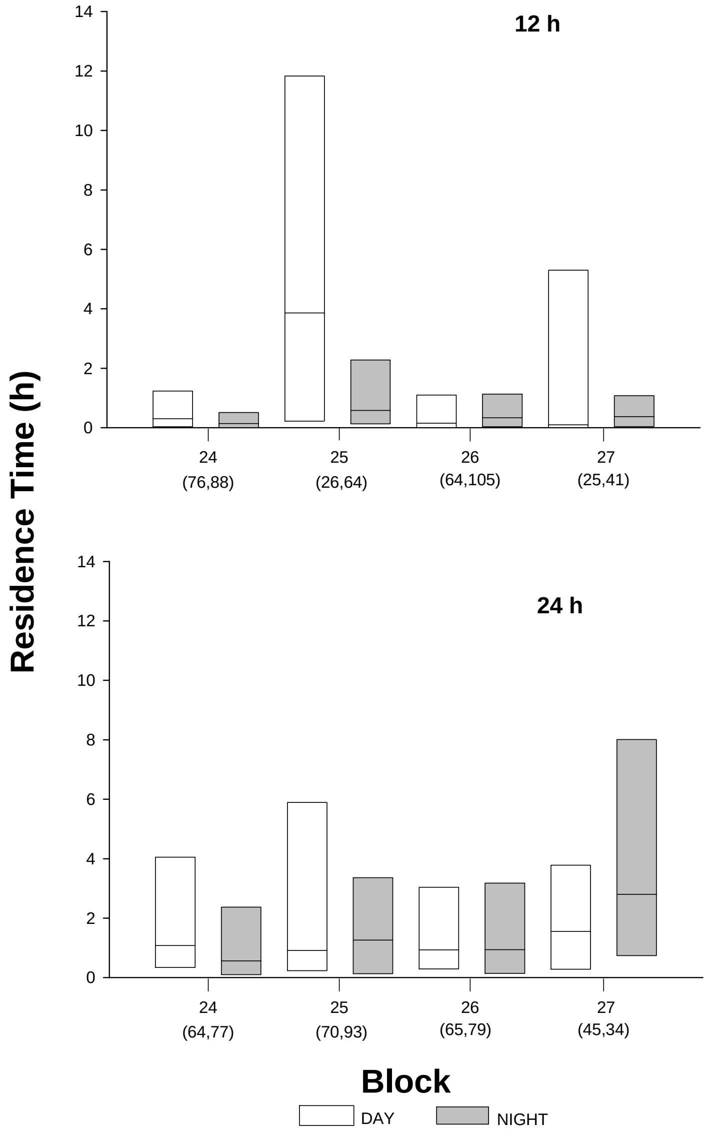


Figure 16. Twenty-fifth, 50th (median), and 75th percentiles (lower, middle, and upper horizontal lines on bars) of radio-tagged subyearling Chinook salmon forebay residence times by diel time of arrival during 12- and 24 h spill treatments at John Day Dam, 11 July through 27 July 2002. 12 h = 0% day spill and 60% night spill, 24 h = 30% day and night spill. Sample sizes are in parentheses (day, night).

Time and General Route of Passage

The time of day that radio-tagged fish passed JDA was similar to their time of arrival, due to the short forebay residence times. In general, passage was similar during most of the day and night, with small peaks in passage present shortly after dusk and again during midday (Figure 17). Night passage (59%) was slightly greater than day passage during the 12 h treatment. Day and night passages were equal during the 24 h treatment (50% in each period).

Diel and treatment differences in the proportion of radio-tagged fish passing via the major passage routes were evident (Figure 18). During the 12 h treatment most subyearling Chinook salmon passed via the JBS during the day (54.2% of 205) and most passed via the spillway at night (73.3% of 295). Turbine passage during the 12 h treatment was greater during the day (45.8% of 205) than at night (15.3% of 295). During the 24 h treatment the spillway was a more common passage route during the day (65.9% of 288) than the night (50.1% of 283), and the percentage passing via the JBS was equal during both periods (13.6%). Turbine passage during this treatment was greater during the night (36.3% of 283) than the day (20.6% of 288).

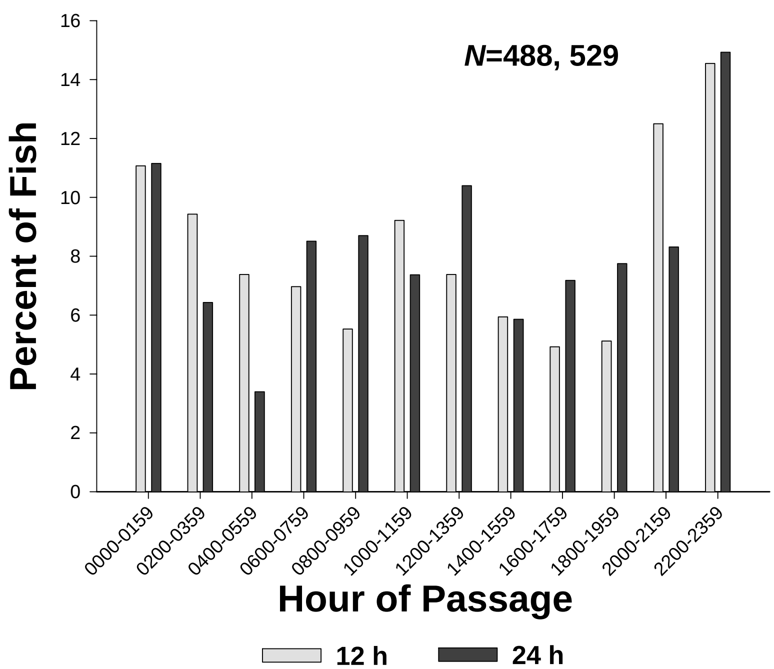


Figure 17. Hour of passage (2-h intervals) of radio-tagged subyearling Chinook salmon, John Day Dam, 11 July through 27 July 2002. All fish were released 23 km upriver of the dam near Rock Creek, Washington. 12 h = 0% day spill and 60% night spill, 24 h = 30% day and night spill. *N* = sample size (12 h, 24 h).

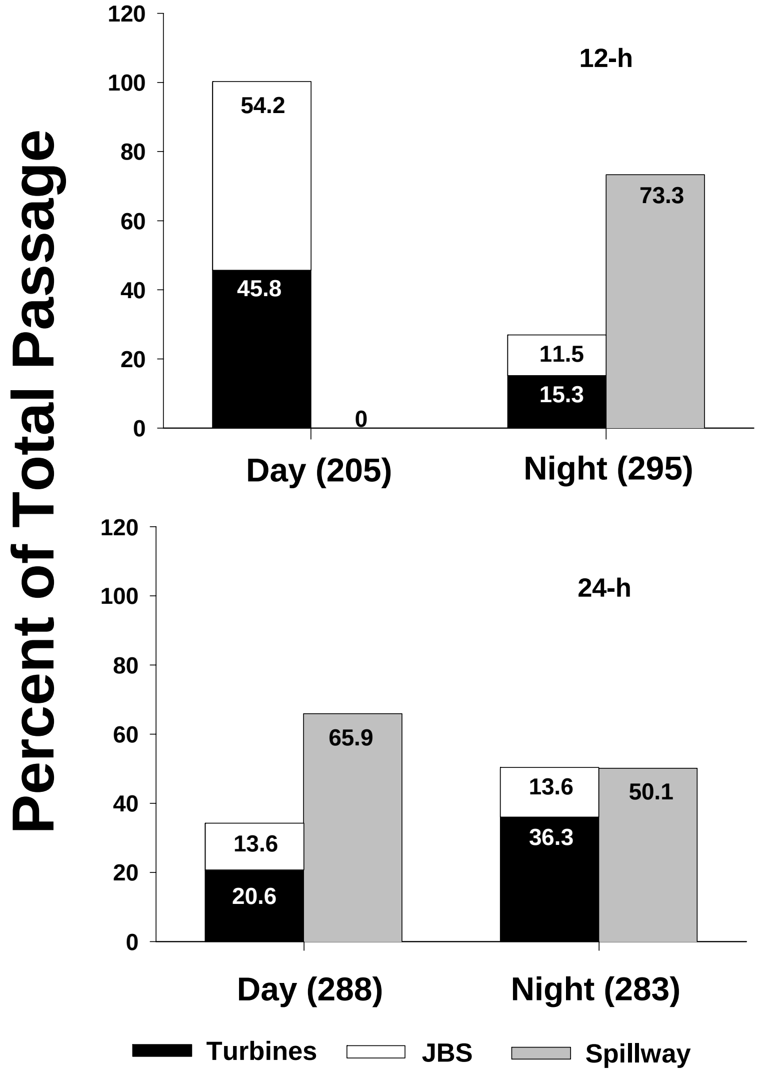


Figure 18. Radio-tagged subyearling Chinook salmon passage via the turbines, juvenile fish bypass system (JBS), and spillway at John Day Dam 11 July through 27 July 2002. Day and night refer to 12 h operational spill periods. 12 h = 0% day spill and 60% night spill, 24 h = 30% day and night spill. Sample sizes are in parentheses. Actual percent passage is on bars.

Fish, Spill, and Juvenile Fish Bypass Passage Efficiencies

With diel periods pooled, there were no significant differences between treatments in subyearling Chinook salmon FPE, but there were significant differences in SPE and JBYPE. The FPE was 72% during the 12 h treatment and 70% during the 24 h treatment (Table 9, $P = 0.5172$, Appendix S). The SPE was greatest during the 24 h treatment (58% vs. 42%, $P < 0.0001$) and the JBYPE was greatest during the 12 h treatment (30 vs. 12%, $P < 0.0001$, Appendices T and U). Numbers of fish passing the turbines, spillway, and juvenile bypass system by date, block, treatment, and diel period are in Appendix V.

Table 9. Diel fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and SLPE) estimates (Est) of subyearling Chinook salmon detected, summer 2002. *N*= sample size. LRCI= profile-likelihood confidence interval.

Passage efficiency	Treatment	12 h			24 h		
		Est	95%LRCI	*N*	Est	95%LRCI	*N*
FPE	Day	54.6	47.8-61.4	205	79.5	74.6-83.9	288
	Night	83.7	77.9-88.6	295	61.1	53.7-68.2	283
	Overall	71.8	67.8-75.6	500	70.4	66.6-74.1	571
SPE	Day	N/A	N/A	205	66.0	66.0-66.0	288
	Night	70.5	61.6-78.5	295	49.5	40.1-58.9	283
	Overall	41.6	34.6-48.9	500	57.8	51.0-64.4	571
JBYPE	Day	54.6	47.8-61.4	205	13.5	9.9-17.8	288
	Night	13.2	8.0-20.0	295	11.7	6.7-18.3	283
	Overall	30.2	26.3-34.3	500	12.6	10.1-15.5	571

There were significant differences between treatments when passage efficiencies were analyzed by diel period. During the day the FPE was significantly greater during the 24 h treatment (80 vs. 55%, $P < 0.0001$) and at night it was significantly greater during the 12 h treatment (84 vs. 61%, $P < 0.0001$, Appendix W). The SPE at night was greater during the 12 h treatment (71 vs. 50%, $P < 0.0001$, Appendix X). No comparisons of SPE during the day were made due to the lack of spill during the 12 h treatment. During the day the JYBPE was greatest during the 12 h treatment (55 vs. 14%, $P < 0.0001$) and at night it was similar between treatments (13 vs. 12%, $P = 0.8359$, Appendix Y). Trends in FPE, SPE, and JBYPE were more similar among blocks during the day than the night (Figure 19). The SPE increased slightly and the JBYPE decreased slightly over time during the 24 h treatment at night.

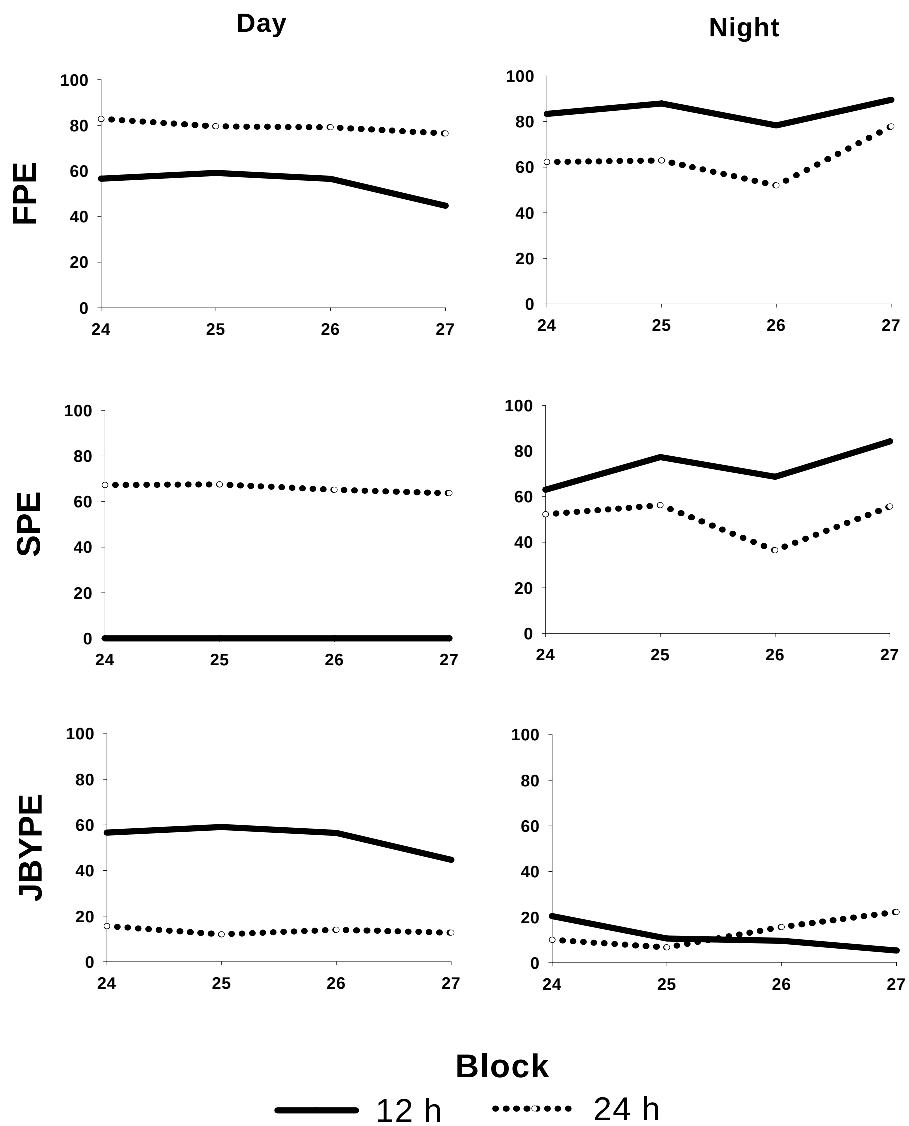


Figure 19. Diel estimates of radio-tagged subyearling Chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE), and juvenile fish bypass efficiency by block at John Day Dam 11 July through 27 July 2002. 12 h = 0% day spill and 60% night spill, 24 h = 30% day and night spill.

Spill Effectiveness

The spill effectiveness was greatest during the 24 h treatment in the day, followed by the 12 h treatment at night and the 24 h treatment at night (Table 9).

Table 9. Spill effectiveness of subyearling Chinook salmon at John Day Dam in 2002. na= not applicable due to little or no spill present.

Treatment	Day	Night
12 h	na	1.22
24 h	2.24	1.65

Discussion

Results from this study indicated no significant effect of the treatments on overall FPE of juvenile steelhead, yearling Chinook salmon, or subyearling Chinook salmon. There were significant differences in SPE and JBYPE, but these offset one another and resulted in no overall difference in FPE. For example, the SPE of subyearling Chinook salmon was significantly greater during the 24 h treatment (58% vs. 42%) and their JBYPE was significantly greater during the 12 h treatment (30% vs. 13%), but the resulting FPE during the two treatments were not significantly different (72% vs. 70%). This trend was also found in the studies of 12 h and 24 h spill during 1999 and 2000, though the treatments have been slightly different among years. In 1999 Hansel et al. (2000a, 2000b) tested a 12 h treatment of 0% day and 45% night spill vs. a 24 h treatment of 30% day and 45% night spill and found results similar to those of this study. In 2000, Beeman et al. (2003) tested passage during 0% day/53% night and 30% day/53% night treatments and found similar results to those of this study in the spring migrants, but not for subyearling Chinook salmon. In the 2000 study, the FPE of subyearling Chinook salmon was significantly greater in the 24 h treatment (91%) than in the 12 h treatment (79%). This difference is likely due to the increased spill during the 24 h treatment in 2000 relative to those used in 1999 and 2002.

There were several significant differences in passage metrics between treatments during day and night periods. These were generally expected based on the proportions of water passing the spillway and turbines in the day and night during each treatment. For example, the FPE of yearling Chinook salmon during the day was greatest during the 24 h treatment (92% vs. 74%) and during the night was greatest during the 12 h treatment

(91% vs. 73%). These results can be attributed to the presence of 30% day spill during the 24 h treatment and its absence during the alternate treatment and presence of 60% night spill during the 12 h treatment and only 30% night spill during the 24 h treatment. This pattern was similar in passage of subyearling Chinook salmon, but not in juvenile steelhead. The FPE of juvenile steelhead at night was similar between treatments. Few juvenile steelhead passed the dam in the day during either treatment and they passed at night in about equal proportions during 30% and 60% spill. This represents a difference in passage behavior between juvenile steelhead both yearling and subyearling Chinook salmon. Studies at John Day Dam in 1999 and 2000 also found few juvenile steelhead passing during the day during no spill and 30% spill treatments, though they were based on fish of hatchery origin and we used juvenile steelhead of wild origin in this study (Hansel et al. 2000, Beeman et al. 2003). Thus, these aspects of juvenile steelhead passage behavior appear to be similar for hatchery and wild fish.

Our results differ from those of a concurrent passage study based on fixed hydroacoustics. Moursund et al. (2003) reported spring FPE point estimates of 93.8% (95% CI ± 2.5) and 89.3% (± 2.4) during 12- and 24 h treatments during the spring and 91.6% (± 1.0) and 88.0% (± 0.9) during these treatments in the summer. These are within the 95% CI bounds of our estimates of FPE of juvenile steelhead in the spring, but are 1.6 to 3.9 units greater than the upper bounds of our estimates of yearling Chinook salmon FPE and 15 and 13 units greater than our bounds of subyearling Chinook salmon FPE. Differences between the study of Moursund et al. (2003) and ours include study periods, species-specificity of our study in the spring, and the obvious differences in methodology including the presence of the transmitter in the radio-tagged fish and the method used for assigning presence or absence of fish. Study dates during the spring were 18 April to 6 June for hydroacoustics and 29 April to 4 June for radio telemetry, and in the summer they were 6 June to 15 July and 24 June to 25 July. The dates of our study were later in the spring and summer due to the minimum fish size needed for implanting radio tags, and may have contributed to the differences in the results of the two studies. The data in the hydroacoustic study was based on a composite of juvenile salmonids, including steelhead, Chinook salmon, sockeye salmon and coho salmon which are also a likely contributor to differences in the two studies. This potential source of difference does not apply to the data collected during the summer.

The goal of the spill tests at John Day Dam is to improve the passage survival of juvenile salmonids. Despite the lack of changes in FPE, differences in survival resulted from altering the spill regimes in 2002. Counihan et al. (2003) found that the survival of radio-tagged yearling Chinook salmon and subyearling Chinook salmon passing via the juvenile bypass system were significantly greater at night during 30% spill (24 h treatment) than 60% spill (12 h treatment) based on a paired-release-recapture model; no significant difference was detected in juvenile steelhead survival through the juvenile bypass system. Smith et al. (2004) found tailrace egress times and paths of radio-tagged fish and GPS-equipped drogues passing via the bypass system took longer to exit the tailrace during 60% spill compared to 30% spill, noting they were often caught within a large gyre in the turbines tailrace at the higher spill level. Thus, a combination of studies of dam passage routes, tailrace egress routes, and survival through various passage routes can provide a more complete evaluation of changes in dam operations than a study limited to one particular passage metric. We suggest future studies of the effects of altered dam operations or structures be evaluated with such a holistic approach.

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Appendices

Appendix A. Spill operations test study design at John Day Dam for blocks used in analysis, spring and summer 2002. Treatment = spill percent day/ spill percent night.

Spring Study

Block	Date	Treatment	Day of Week	Block	Date	Treatment	Day of Week
6	30-Apr	30/30	Tue	9	14-May	00/60	Tue
6	1-May	30/30	Wed	9	15-May	00/60	Wed
6	2-May	00/60	Thu	10	16-May	00/60	Thu
6	3-May	00/60	Fri	10	17-May	00/60	Fri
7	4-May	30/30	Sat	10	18-May	30/30	Sat
7	5-May	30/30	Sun	10	19-May	30/30	Sun
7	6-May	00/60	Mon	11	20-May	30/30	Mon
7	7-May	00/60	Tue	11	21-May	30/30	Tue
8	8-May	00/60	Wed	11	22-May	00/60	Wed
8	9-May	00/60	Thu	11	23-May	00/60	Thu
8	10-May	30/30	Fri	12	24-May	00/60	Fri
8	11-May	30/30	Sat	12	25-May	00/60	Sat
9	12-May	30/30	Sun	12	26-May	30/30	Sun
9	13-May	30/30	Mon	12	27-May	30/30	Mon

Summer Study

Block	Date	Treatment	Day of Week	Block	Date	Treatment	Day of Week
24	11-Jul	00/60	Tue	26	19-Jul	30/30	Wed
24	12-Jul	00/60	Wed	26	20-Jul	30/30	Thu
24	13-Jul	30/30	Thu	26	21-Jul	00/60	Fri
24	14-Jul	30/30	Fri	26	22-Jul	00/60	Sat
25	15-Jul	00/60	Sat	27	23-Jul	00/60	Sun
25	16-Jul	00/60	Sun	27	24-Jul	00/60	Mon
25	17-Jul	30/30	Mon	27	25-Jul	30/30	Tue
25	18-Jul	30/30	Tue	27	26-Jul	30/30	Wed

Appendix B. Release date, release time (hours), number released, percent detected, mean, standard deviation (SD), and range of fork lengths (mm), and weights (g) of juvenile steelhead released into Rock Creek above John Day Dam during spring 2002.

Release	Release	Number	Percent	Fork length (mm)			Weight (g)		
Date	Time	Released	Detected	Mean	SD	Range	Mean	SD	Range
29-Apr	2100	11	90.9	192.5	16.8	164-223	65.7	15.5	42.5-96.2
30-Apr	0900	6	83.3	190.3	12.4	178-212	58.7	13.3	44.5-82.0
1-May	2100	12	100.0	186.8	22.4	158-235	63.2	24.6	34.2-124.7
2-May	0900	15	93.3	192.3	12.9	167-214	62.7	13.9	34.4-84.8
3-May	2100	19	100.0	192.8	14.4	173-223	63.1	16.2	44.2-91.7
4-May	0900	18	88.9	181.7	13.6	157-205	54.2	12.8	32.0-75.0
5-May	2100	12	83.3	188.7	24.5	152-234	60.4	21.4	31.1-98.4
6-May	0900	12	100.0	190.9	24.6	158-257	65.7	28.3	35.1-139.6
7-May	2100	22	90.9	188.9	27.3	155-242	64	29	35.0-126.6
8-May	0900	16	87.5	190.1	18.7	167-231	64.2	19	43.8-109.1
9-May	2100	18	100.0	200.9	35.1	157-275	79.1	49.2	37.6-202.5
10-May	0900	18	100.0	190	19.8	158-242	61.4	19.7	34.9-110.6
11-May	2100	9	100.0	199.3	28	163-245	78.7	38.2	41.5-164.9
12-May	0900	10	80.0	179.6	18.7	143-200	52.3	15.9	24.1-72.1
13-May	2100	20	95.0	194.9	25.2	146-241	67.2	26.1	25.7-120.8
14-May	0900	24	87.5	192.6	17.4	161-240	62.5	17.2	31.7-112.4
15-May	2100	18	100.0	189.8	17.7	157-218	62.2	16.5	34.1-89.9
16-May	0900	18	100.0	181.9	13.1	160-207	57.2	13.6	38.1-95.4
17-May	2100	20	95.0	191.9	19	157-226	65	16.6	36.6-99.0
18-May	0900	19	100.0	185.3	18.4	159-224	58.6	18.2	34.0-109.6
19-May	2100	17	100.0	199.2	22.4	154-238	78.9	24.1	30.1-121.2
20-May	0900	20	80.0	187.3	16.1	154-212	61.9	17.5	32.5-90.0
21-May	2100	19	84.2	189.6	17.9	160-227	62.4	20.6	33.0-109.9
22-May	0900	19	94.7	186.9	20	154-227	63.3	23.1	33.6-114.3
23-May	2100	20	100.0	199.9	24.2	160-255	75.9	28.9	31.0-146.7
24-May	0900	18	94.4	188	11.9	169-210	62.7	13.1	35.8-80.7
25-May	2100	17	100.0	192.4	19.2	154-232	66.7	19.8	32.7-115.4
26-May	0900	20	90.0	185	17.5	161-217	57	15.1	36.0-90.0
27-May	2100	20	80.0	191.4	28	155-275	65.9	29.5	29.6-162.1
28-May	900	18	88.9	192	19.4	146-224	63.8	17.6	27.4-90.3
29-May	2100	21	90.5	183.9	13.8	156-207	58.2	14.9	33.1-88.7
30-May	0900	20	85.0	189.2	29.8	143-260	65.4	34.9	28.7-156.5
3-Jun	2100	27	92.6	194.2	22	160-258	68.3	24.1	35.4-146.6
4-Jun	0900	29	86.2	183.6	14.4	153-223	56.6	15.9	27.1-91.4
Overall		602	92.4	189.9	20.4	143-275	63.6	22.6	24.1-202.5

Appendix C. Release date, release time (hours), number released, percent detected, mean, standard deviation (SD), and range of fork lengths (mm), and weights (g) of yearling Chinook salmon released into Rock Creek above John Day Dam during spring 2002.

Release	Release	Number	Percent	Fork length (mm)			Weight (g)		
Date	Time	Released	Detected	Mean	SD	Range	Mean	SD	Range
29-Apr	2100	46	97.8	150.2	10.3	134-179	33.7	7.3	23.8-57.5
30-Apr	0900	45	80.0	151.3	15.4	128-191	34.9	11.3	23.1-68.5
1-May	2100	48	89.5	150.7	12.2	125-179	34.9	9.3	19.8-61.9
2-May	0900	44	90.9	149.3	12.4	133-194	33.6	9.2	22.6-74.5
3-May	2100	47	93.6	146.7	13.6	116-170	33	7.6	15.8-51.8
4-May	0900	54	96.3	151	10.9	129-181	33.8	7.9	22.3-58.7
5-May	2100	51	94.1	150.5	10.9	132-180	33.7	8.1	22.4-57.9
6-May	0900	44	95.5	147.8	11.8	124-188	33.9	9.3	20.9-71.4
7-May	2100	46	89.1	147.7	11.5	124-175	31.5	7.5	17.6-54.8
8-May	0900	48	93.8	152	12.6	129-196	34.2	10	19.2-76.2
9-May	2100	49	100.0	146.4	11.6	130-176	31.5	8.1	22.0-53.7
10-May	0900	48	93.8	148.8	13.2	127-185	33.6	9	19.1-62.7
11-May	2100	50	96.0	147.8	14.7	120-182	34.1	10.1	19.2-57.6
12-May	0900	45	91.1	146.5	14	126-186	29.5	9.7	17.8-60.0
13-May	2100	55	92.7	143.8	13	121-177	28.7	8.2	16.5-50.7
14-May	0900	47	89.4	145.6	12.1	124-186	30.7	8.8	18.3-65.1
15-May	2100	49	83.7	140.1	15	120-186	28.8	10.4	16.0-65.5
16-May	0900	49	87.8	143.6	13.8	120-176	30	8.8	16.6-54.6
17-May	2100	46	84.8	144.9	15.2	124-191	30.4	10.9	18.2-67.6
18-May	0900	48	79.2	142.3	15.6	120-205	28.5	11.6	17.6-82.8
19-May	2100	46	89.1	141.8	10.4	120-175	27.5	6.7	17.3-50.9
20-May	0900	54	79.6	141.4	12.9	125-191	25.7	8.6	17.2-65.8
21-May	2100	53	94.3	148.5	17.8	122-204	31.3	12.8	17.3-81.0
22-May	0900	49	98.0	149	17.5	120-190	33.1	12.7	18.3-72.6
23-May	2100	52	94.2	149.9	19	123-192	35	12.7	19.0-66.4
24-May	0900	52	86.5	146.5	17.2	124-187	33.2	11.7	19.8-65.4
25-May	2100	49	91.8	153.1	18.3	130-205	37.6	15	21.6-85.4
26-May	0900	49	89.8	148.6	16.4	122-196	33.6	11.8	19.1-72.3
27-May	2100	52	88.5	147.6	16.2	121-185	31	10.6	17.3-61.8
28-May	0900	53	92.5	156.7	16.5	126-190	38.6	11.7	18.4-64.4
29-May	2100	49	95.9	155.1	18.2	124-200	36.8	12.5	19.1-65.3
30-May	0900	52	96.2	157.7	18.1	128-201	39.8	14	18.0-82.9
Overall		1569	91.1	148.3	15	116-205	32.7	10.7	15.8-85.4

Appendix D. Juvenile steelhead spillway (SP), turbines (TU), and juvenile fish bypass (JBS) passage counts by block, treatment, date and diel at John Day Dam, spring 2002.

Species	Block	Trt	Date	Diel	SP	TU	JBS
STH	6	24 h	4/30/02	Night	0	0	1
STH	6	24 h	5/1/02	Day	0	0	1
STH	6	24 h	5/1/02	Night	1	0	3
STH	6	12 h	5/2/02	Day	0	0	1
STH	6	12 h	5/2/02	Night	0	0	1
STH	6	24 h	5/2/02	Night	3	0	1
STH	6	12 h	5/3/02	Day	0	2	3
STH	6	12 h	5/3/02	Night	4	0	7
STH	6	12 h	5/4/02	Night	5	0	2
STH	7	24 h	5/4/02	Day	2	0	0
STH	7	24 h	5/4/02	Night	0	0	2
STH	7	24 h	5/5/02	Day	1	0	1
STH	7	24 h	5/5/02	Night	1	0	7
STH	7	12 h	5/6/02	Day	0	1	3
STH	7	12 h	5/6/02	Night	2	0	0
STH	7	24 h	5/6/02	Night	3	2	5
STH	7	12 h	5/7/02	Day	0	0	1
STH	7	12 h	5/7/02	Night	6	0	4
STH	7	12 h	5/8/02	Night	12	1	2
STH	8	12 h	5/8/02	Day	1	0	1
STH	8	12 h	5/8/02	Night	12	0	0
STH	8	12 h	5/9/02	Day	0	1	1
STH	8	12 h	5/9/02	Night	13	3	1
STH	8	12 h	5/10/02	Night	2	0	0
STH	8	24 h	5/10/02	Night	0	0	1
STH	8	24 h	5/11/02	Day	8	0	0
STH	8	24 h	5/11/02	Night	14	1	0
STH	8	24 h	5/12/02	Night	2	0	2
STH	9	24 h	5/12/02	Day	1	0	0
STH	9	24 h	5/12/02	Night	5	0	0
STH	9	24 h	5/13/02	Day	0	1	0
STH	9	24 h	5/13/02	Night	5	0	4
STH	9	12 h	5/14/02	Day	1	0	0
STH	9	12 h	5/14/02	Night	0	0	2
STH	9	24 h	5/14/02	Night	0	0	2
STH	9	12 h	5/15/02	Day	0	1	1
STH	9	12 h	5/15/02	Night	6	0	6

Appendix D. Continued.

STH	9	24 h	5/15/02	Night	2	0	0
STH	9	12 h	5/16/02	Night	5	0	0
STH	10	12 h	5/16/02	Day	0	1	1
STH	10	12 h	5/16/02	Night	3	0	1
STH	10	12 h	5/17/02	Day	0	0	2
STH	10	12 h	5/17/02	Night	20	2	5
STH	10	24 h	5/17/02	Night	3	0	0
STH	10	12 h	5/18/02	Night	7	3	2
STH	10	24 h	5/18/02	Day	2	0	0
STH	10	24 h	5/18/02	Night	0	0	3
STH	10	24 h	5/19/02	Day	6	1	0
STH	10	24 h	5/19/02	Night	8	5	1
STH	10	24 h	5/20/02	Night	2	0	1
STH	11	24 h	5/20/02	Day	2	2	0
STH	11	24 h	5/20/02	Night	1	0	2
STH	11	24 h	5/21/02	Day	5	1	0
STH	11	24 h	5/21/02	Night	3	2	7
STH	11	12 h	5/22/02	Day	0	0	1
STH	11	12 h	5/22/02	Night	6	1	1
STH	11	24 h	5/22/02	Night	4	2	4
STH	11	12 h	5/23/02	Day	0	1	2
STH	11	12 h	5/23/02	Night	19	1	2
STH	11	12 h	5/24/02	Night	0	1	1
STH	12	12 h	5/24/02	Day	1	0	4
STH	12	12 h	5/24/02	Night	10	0	2
STH	12	12 h	5/25/02	Day	0	1	4
STH	12	12 h	5/25/02	Night	11	1	1
STH	12	12 h	5/26/02	Night	3	0	0
STH	12	24 h	5/26/02	Day	2	1	0
STH	12	24 h	5/26/02	Night	1	0	0
STH	12	24 h	5/27/02	Day	7	0	2
STH	12	24 h	5/27/02	Night	4	1	6
STH	12	24 h	5/28/02	Night	3	1	3

Appendix E. Yearling Chinook salmon spillway (SP), turbines (TU), and juvenile fish bypass (JBS) passage counts by block, treatment, date and diel at John Day Dam, spring 2002.

Species	Block	Trt	Date	Diel	SP	TU	JBS
CH1	6	24 h	4/30/02	Day	1	0	0
CH1	6	24 h	4/30/02	Night	5	5	7
CH1	6	24 h	5/1/02	Day	16	0	8
CH1	6	24 h	5/1/02	Night	8	7	10
CH1	6	12 h	5/2/02	Day	0	2	3
CH1	6	12 h	5/2/02	Night	16	2	7
CH1	6	24 h	5/2/02	Night	4	0	3
CH1	6	12 h	5/3/02	Day	0	1	18
CH1	6	12 h	5/3/02	Night	14	3	9
CH1	6	24 h	5/3/02	Night	1	0	0
CH1	6	12 h	5/4/02	Night	6	0	1
CH1	7	24 h	5/4/02	Day	13	2	4
CH1	7	24 h	5/4/02	Night	5	3	11
CH1	7	24 h	5/5/02	Day	17	1	1
CH1	7	24 h	5/5/02	Night	11	13	12
CH1	7	12 h	5/6/02	Day	0	5	9
CH1	7	12 h	5/6/02	Night	16	4	2
CH1	7	24 h	5/6/02	Night	1	2	1
CH1	7	12 h	5/7/02	Day	0	5	16
CH1	7	12 h	5/7/02	Night	25	0	4
CH1	7	12 h	5/8/02	Night	3	0	0
CH1	8	12 h	5/8/02	Day	0	1	12
CH1	8	12 h	5/8/02	Night	17	0	3
CH1	8	12 h	5/9/02	Day	0	4	10
CH1	8	12 h	5/9/02	Night	21	4	8
CH1	8	12 h	5/10/02	Night	2	0	0
CH1	8	24 h	5/10/02	Day	17	3	2
CH1	8	24 h	5/10/02	Night	4	4	4
CH1	8	24 h	5/11/02	Day	23	3	8
CH1	8	24 h	5/11/02	Night	10	7	9
CH1	8	24 h	5/12/02	Night	1	0	0
CH1	9	24 h	5/12/02	Day	13	0	0
CH1	9	24 h	5/12/02	Night	17	0	2
CH1	9	24 h	5/13/02	Day	27	7	6
CH1	9	24 h	5/13/02	Night	5	6	8
CH1	9	12 h	5/14/02	Day	0	8	10
CH1	9	12 h	5/14/02	Night	21	2	1

Appendix E. Continued.

CH1	9	24 h	5/14/02	Night	0	0	2
CH1	9	12 h	5/15/02	Day	0	4	12
CH1	9	12 h	5/15/02	Night	21	3	5
CH1	9	12 h	5/16/02	Night	2	0	0
CH1	10	12 h	5/16/02	Day	0	3	2
CH1	10	12 h	5/16/02	Night	17	0	3
CH1	10	12 h	5/17/02	Day	0	9	12
CH1	10	12 h	5/17/02	Night	29	5	2
CH1	10	12 h	5/18/02	Night	0	1	1
CH1	10	24 h	5/18/02	Day	12	0	1
CH1	10	24 h	5/18/02	Night	4	4	6
CH1	10	24 h	5/19/02	Day	16	2	5
CH1	10	24 h	5/19/02	Night	15	5	5
CH1	10	24 h	5/20/02	Night	1	0	0
CH1	11	24 h	5/20/02	Day	17	1	5
CH1	11	24 h	5/20/02	Night	4	2	3
CH1	11	24 h	5/21/02	Day	13	2	9
CH1	11	24 h	5/21/02	Night	8	12	9
CH1	11	12 h	5/22/02	Day	1	7	26
CH1	11	12 h	5/22/02	Night	33	5	4
CH1	11	24 h	5/22/02	Night	2	0	2
CH1	11	12 h	5/23/02	Day	0	0	1
CH1	11	12 h	5/23/02	Night	8	5	6
CH1	12	12 h	5/24/02	Day	0	6	16
CH1	12	12 h	5/24/02	Night	18	1	1
CH1	12	24 h	5/24/02	Night	3	0	0
CH1	12	12 h	5/25/02	Day	0	2	10
CH1	12	12 h	5/25/02	Night	20	2	8
CH1	12	12 h	5/26/02	Night	1	0	1
CH1	12	24 h	5/26/02	Day	14	0	5
CH1	12	24 h	5/26/02	Night	6	2	2
CH1	12	24 h	5/27/02	Day	22	3	3
CH1	12	24 h	5/27/02	Night	11	7	2
CH1	12	24 h	5/28/02	Night	4	2	2

Appendix F. Overall estimates of wild juvenile steelhead fish passage efficiency (FPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
6	92.3	26	11.987	100.0	9	-	-
7	93.8	32	15.129	91.7	24	11.048	0.730
8	88.6	35	7.772	96.4	28	26.778	3.445
9	95.8	24	22.810	94.4	18	16.857	0.739
10	86.3	51	6.299	79.3	29	3.831	0.608
11	89.2	37	8.259	79.4	34	3.854	0.467
12	94.7	38	17.868	90.3	31	9.309	0.521

Overall odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.760 (0.395 - 1.467)

Test HO: odds ratio = 1 (no treatment effect), *P* = 0.4095

Appendix G. Overall estimates of yearling Chinook salmon fish passage efficiency (FPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
6	90.4	83	9.417	83.6	73	5.098	0.541
7	84.3	89	5.369	78.4	97	3.630	0.676
8	89.0	82	8.091	80.4	95	4.102	0.507
9	80.9	89	4.236	86.0	93	6.143	1.450
10	78.3	83	3.608	85.6	76	5.944	1.647
11	82.7	98	4.780	80.2	86	4.051	0.847
12	87.6	89	7.065	86.6	85	6.463	0.915

Overall odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.847 (0.624 - 1.148)

Test HO: odds ratio = 1 (no treatment effect), *P* = 0.2839

Appendix H. Overall estimates of wild juvenile steelhead spill passage efficiency (SPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	SPE	*N*	Odds	SPE	*N*	Odds	Odds Ratio
6	38.5	26	0.626	33.3	9	0.499	0.798
7	62.5	32	1.667	29.2	24	0.412	0.247
8	80.0	35	4.000	85.7	28	5.993	1.498
9	58.3	24	1.398	61.1	18	1.571	1.123
10	64.7	51	1.833	62.1	29	1.639	0.894
11	70.3	37	2.367	41.2	34	0.701	0.296
12	65.8	38	1.924	54.8	31	1.212	0.630

Overall odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.605 (0.398 - 0.916)

Test HO: odds ratio = 1 (no treatment effect), $P = 0.0174$

Appendix I. Overall estimates of yearling Chinook salmon spill passage efficiency (SPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	SPE	*N*	Odds	SPE	*N*	Odds	Odds Ratio
6	44.6	83	0.805	46.6	73	0.873	1.084
7	49.4	89	0.976	48.5	97	0.942	0.965
8	48.8	82	0.953	56.7	97	1.309	1.374
9	49.4	89	0.976	66.7	93	2.003	2.052
10	54.2	83	1.183	63.2	76	1.717	1.451
11	44.9	98	0.815	47.7	86	0.912	1.119
12	47.2	89	0.894	67.1	85	2.040	2.281

Overall odds ratio adjusted for blocks 6 - 12 (95% LRCI) 1.399 (1.115 - 1.756)

Test HO: odds ratio = 1 (no treatment effect), $P = 0.0037$

Appendix J. Overall estimates of wild juvenile steelhead bypass passage efficiency (JBYPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
6	53.8	26	1.165	66.7	9	2.003	1.720
7	31.3	32	0.456	62.5	24	1.667	3.658
8	8.6	35	0.094	10.7	28	0.120	1.273
9	37.5	24	0.600	33.3	18	0.499	0.832
10	21.6	51	0.276	17.2	29	0.208	0.754
11	18.9	37	0.233	38.2	34	0.618	2.652
12	28.9	38	0.406	35.5	31	0.550	1.354

Overall odds ratio adjusted for blocks 6 - 12 (95% LRCI) 1.586 (1.012 - 2.494)

Test HO: odds ratio = 1 (no treatment effect), $P = 0.0441$

Appendix K. Overall estimates of yearling Chinook salmon bypass passage efficiency (JBYPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
6	45.8	83	0.845	37.0	73	0.587	0.695
7	34.8	89	0.534	29.9	97	0.427	0.799
8	40.2	82	0.672	23.7	97	0.311	0.462
9	31.5	89	0.460	19.4	93	0.241	0.523
10	24.1	83	0.318	22.4	76	0.289	0.909
11	37.8	98	0.608	32.6	86	0.484	0.796
12	40.4	89	0.678	16.5	85	0.198	0.292

Overall odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.605 (0.472 - 0.774)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix L. Diel estimates of wild juvenile steelhead fish passage efficiency (FPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Night							
	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
6	100.0	20	-	100.0	8	-	-
7	96.3	27	26.027	90.0	20	9.000	0.346
8	90.3	31	9.309	95.0	20	19.000	2.041
9	100.0	21	-	100.0	16	-	-
10	87.2	47	6.813	75.0	20	3.000	0.440
11	90.9	33	9.989	83.3	24	4.988	0.499
12	96.4	28	26.778	89.5	19	8.524	0.318

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.532 (0.238 - 1.187)

Test HO: odds ratio = 1 (no treatment effect), *P* = 0.1231

Appendix M. Diel estimates of wild juvenile steelhead spill passage efficiency (SPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Night							
	12 h			24 h			Observed
Block	SPE	*N*	Odds	SPE	*N*	Odds	Odds Ratio
6	50.0	20	1.000	37.5	8	0.600	0.600
7	74.1	27	2.861	20.0	20	0.250	0.087
8	87.1	31	6.752	80.0	20	4.000	0.592
9	61.9	21	1.625	62.5	16	1.667	1.026
10	70.2	47	2.356	50.0	20	1.000	0.425
11	78.8	33	3.717	29.2	24	0.412	0.111
12	85.7	28	5.993	42.1	19	0.727	0.121

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.265 (0.127 - 0.535)

Test HO: odds ratio = 1 (no treatment effect), *P* = 0.0002

Appendix N. Diel estimates of wild juvenile steelhead bypass passage efficiency (JBYPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Night							
	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
6	50.0	20	1.000	62.5	8	1.667	1.667
7	22.2	27	0.285	70.0	20	2.333	8.177
8	3.2	31	0.033	15.0	20	0.176	5.338
9	38.1	21	0.616	37.5	16	0.600	0.975
10	17.0	47	0.205	25.0	20	0.333	1.627
11	12.1	33	0.138	54.2	24	1.183	8.597
12	10.7	28	0.120	47.4	19	0.901	7.521

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 3.636 (2.156 - 6.230)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix O. Diel estimates of yearling Chinook salmon fish passage efficiency (FPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Day							
	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
6	87.5	24	7.000	100.0	25	-	-
7	71.4	35	2.497	92.1	38	11.658	4.670
8	81.5	27	4.405	89.3	56	8.346	1.894
9	64.7	34	1.833	86.8	53	6.576	3.588
10	53.8	26	1.165	94.4	36	16.857	14.476
11	80.0	35	4.000	93.5	46	14.385	3.596
12	76.5	34	3.255	93.6	47	14.625	4.493

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 4.429 (2.651 - 7.603)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Night							
	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
6	91.5	59	10.765	75.0	48	3.000	0.279
7	92.6	54	12.514	69.5	59	2.279	0.182
8	92.7	55	12.699	71.8	39	2.546	0.201
9	90.9	55	9.989	85.0	40	5.667	0.567
10	89.5	57	8.524	77.5	40	3.444	0.404
11	84.1	63	5.289	65.0	40	1.857	0.351
12	94.5	55	17.182	71.1	38	2.460	0.143

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.277 (0.179 - 0.421)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix P. Diel estimates of yearling Chinook salmon spill passage efficiency (SPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Night							
	12 h			24 h			Observed
Block	SPE	*N*	Odds	SPE	*N*	Odds	Odds Ratio
6	62.7	59	1.681	35.4	48	0.548	0.326
7	81.5	54	4.405	28.8	59	0.404	0.092
8	72.7	55	2.663	38.5	39	0.626	0.235
9	80.0	55	4.000	55.0	40	1.222	0.306
10	78.9	57	3.739	50.0	40	1.000	0.267
11	68.3	63	2.155	30.0	40	0.429	0.199
12	76.4	55	3.237	55.3	38	1.237	0.382

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.235 (0.169 - 0.325)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix Q. Diel estimates of yearling Chinook salmon bypass passage efficiency (JBYPE) during the two spill treatments by block and logistic regression results comparing the treatments, 30 April through 28 May 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Day							
	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
6	87.5	24	7.000	32.0	25	0.471	0.067
7	71.4	35	2.497	13.2	38	0.152	0.061
8	81.5	27	4.405	17.9	56	0.218	0.049
9	64.7	34	1.833	11.3	53	0.127	0.070
10	53.8	26	1.165	16.7	36	0.200	0.172
11	77.1	35	3.367	30.4	46	0.437	0.130
12	76.5	34	3.255	17.0	47	0.205	0.063

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.080 (0.051 - 0.122)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Night							
	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
6	28.8	59	0.404	39.6	48	0.656	1.621
7	11.1	54	0.125	40.7	59	0.686	5.497
8	20.0	55	0.250	33.3	39	0.499	1.997
9	10.9	55	0.122	30.0	40	0.429	3.503
10	10.5	57	0.117	27.5	40	0.379	3.233
11	15.9	63	0.189	35.0	40	0.538	2.848
12	18.2	55	0.222	15.8	38	0.188	0.843

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 2.420 (1.054 - 3.483)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix R. Release date, release time (hours), number released, percent detected, mean, standard deviation (SD), and range of fork lengths (mm), and weights (g) of subyearling Chinook salmon released into Rock Creek above John Day Dam during summer 2002.

Release Date	Release time	Number Released	Percent Detected	Fork length (mm)			Weight (g)		
				Mean	SD	Range	Mean	SD	Range
24-Jun	2100	52	80.8	113.5	2.9	110.0-124.0	15.6	1.3	13.3-20.7
25-Jun	0900	59	83.1	115.3	4.1	111.0-128.0	16.9	2.2	12.8-20.9
25-Jun	2100	65	78.5	113.8	3.1	110.0-122.0	16.9	1.6	13.8-22.2
26-Jun	0900	62	87.1	113	2.8	110.0-123.0	15.7	1.4	13.0-19.4
26-Jun	2100	58	86.2	114.1	3.1	110.0-126.0	16	1.9	12.5-23.8
27-Jun	0900	61	80.3	113	2.4	110.0-121.0	15.2	1.4	13.1-20.3
27-Jun	2100	60	88.3	114.6	3.5	110.0-126.0	15.5	1.6	13.0-20.9
28-Jun	0900	61	88.5	114.2	3.8	110.0-128.0	17	1.9	14.0-23.3
28-Jun	2100	52	88.7	113.6	2.6	110.0-120.0	15.4	1.3	13.5-19.1
29-Jun	0900	65	87.5	114.5	4.2	110.0-132.0	16.4	2.5	11.9-25.7
29-Jun	2100	54	87.0	114.1	4.9	110.0-137.0	17.1	2.4	14.3-28.8
30-Jun	0900	55	83.6	112.9	5	110.0-143.0	15.5	3	12.7-32.6
30-Jun	2100	58	86.2	113.8	4.7	110.0-134.0	15.1	1.9	12.1-23.0
1-Jul	0900	59	84.8	112.1	2.5	110.0-119.0	14.9	1.2	12.9-18.1
1-Jul	2100	37	91.9	114	7	110.0-149.0	16.1	3.9	12.9-35.7
2-Jul	0900	50	92.0	112.7	3	110.0-125.0	15.2	1.6	13.2-21.2
2-Jul	2100	42	73.8	114.3	3.7	110.0-128.0	17.8	2.1	14.1-22.3
3-Jul	0900	32	93.8	114.6	4.6	110.0-125.0	16.4	2.4	12.4-21.3
3-Jul	2100	41	87.8	114.3	3.5	110.0-126.0	15.3	1.6	13.0-20.6
4-Jul	0900	29	86.2	115	6.2	110.0-143.0	17.3	3.1	13.5-31.4
4-Jul	2100	41	70.7	113.9	4.4	110.0-136.0	15.3	2.2	12.3-25.7
5-Jul	0900	41	85.4	114.5	5.7	110.0-135.0	15.9	2.6	13.1-25.6
5-Jul	2100	41	85.0	115.2	6.3	110.0-145.0	17.9	3.4	14.5-34.1
6-Jul	900	41	85.4	115.3	5.8	110.0-141.0	16	2.8	12.9-28.6
6-Jul	2100	45	88.9	114.2	5.2	110.0-138.0	16.2	3.1	11.6-30.3
7-Jul	0900	40	82.5	115.7	6.4	110.0-136.0	17.7	3.2	14.1-26.5
7-Jul	2100	38	86.8	114.4	6.2	110.0-145.0	15.8	3.2	13.2-31.3
8-Jul	0900	33	72.7	114.7	5.5	110.0-135.0	17	2.9	14.1-29.2
8-Jul	2100	59	76.3	116	7.7	110.0-149.0	18.5	3.8	15.0-34.3
9-Jul	0900	44	90.9	116.5	7.2	110.0-151.0	16.5	3.5	13.1-34.4
9-Jul	2100	40	82.1	116.7	6.1	110.0-137.0	17.9	3.5	13.4-29.4
10-Jul	0900	38	92.1	118.7	8.6	110.0-146.0	18.3	4.3	13.0-33.3
10-Jul	2100	47	82.6	117	6.6	111.0-140.0	17.3	3.6	13.8-31.3
11-Jul	0900	43	86.1	117.8	7.8	110.0-148.0	19.9	4.8	14.9-37.4
11-Jul	2100	46	84.8	115.7	6	110.0-138.0	17.3	3.2	13.9-29.6
12-Jul	0900	49	89.8	114	4.5	110.0-128.0	16.1	2.3	13.3-22.6

Appendix R. Continued.

12-Jul	2100	44	75.0	116.5	6.2	110.0-133.0	18	3	13.9-25.5
13-Jul	0900	39	89.7	117.3	6.2	110.0-132.0	19	3.2	14.7-27.1
13-Jul	2100	45	86.7	118.7	6.4	110.0-137.0	17.4	2.9	13.9-28.2
14-Jul	0900	48	87.5	120	6.3	110.0-139.0	18.3	3	14.0-29.2
14-Jul	2100	46	23.9	117.3	5.1	110.0-138.0	18.4	2.4	14.7-27.4
15-Jul	0900	48	85.4	117	7.4	110.0-140.0	17	4.2	13.3-31.0
15-Jul	2100	50	78.0	119	6.3	112.0-141.0	18.7	3.6	14.4-29.2
16-Jul	0900	47	80.9	115.5	6	110.0-135.0	16.8	3.2	12.4-25.5
16-Jul	2100	46	91.3	117.6	6.9	111.0-142.0	18.8	3.8	13.4-31.3
17-Jul	0900	48	77.1	119.3	7	111.0-145.0	19.6	3.8	14.7-33.0
17-Jul	2100	44	84.1	118.9	8.4	110.0-146.0	18.5	4.5	13.9-33.8
18-Jul	0900	51	80.4	120.6	6.1	110.0-137.0	20.1	3.3	14.4-28.7
18-Jul	2100	51	88.0	119.2	7.5	110.0-142.0	19	3.8	13.7-28.6
19-Jul	0900	39	92.3	124.9	7.4	112.0-145.0	21.4	3.9	14.8-33.7
19-Jul	2100	50	92.0	122.9	10.7	111.0-153.0	21.6	6.2	15.0-40.7
20-Jul	0900	51	66.7	120.9	9	111.0-152.0	19.1	4.5	13.3-34.6
20-Jul	2100	45	77.8	119.2	8.1	110.0-141.0	19.5	3.8	13.7-30.0
21-Jul	0900	46	80.4	119.6	7.8	110.0-139.0	19.9	3.6	14.1-28.1
21-Jul	2100	48	68.8	119.6	8.8	110.0-144.0	19.1	4.4	13.8-33.3
22-Jul	0900	46	60.9	116.1	4.5	110.0-128.0	17.2	2.4	12.9-24.4
23-Jul	0900	51	76.5	120.5	8.6	111.0-147.0	18.8	4.2	14.0-35.1
24-Jul	0900	75	46.7	120.9	8.1	110.0-145.0	20.3	4.2	14.3-37.1
25-Jul	0900	89	67.4	123.2	8.5	110.0-146.0	22	5	15.6-43.6
Overall		2885	81.1	116.5	6.8	110.0-153.0	17.6	3.7	11.6-43.6

Appendix S. Overall estimates of subyearling Chinook salmon fish passage efficiency (FPE) during the two spill treatments by block and logistic regression results comparing the treatments, 11 July through 27 July 2002. 12 h= 0% spill during day and 60% spill during the night. 24 h= 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
24	71.7	191	2.534	70.8	154	2.425	0.957
25	80.7	88	4.181	70.9	172	2.436	0.583
26	69.0	145	2.226	66.2	163	1.959	0.880
27	67.1	76	2.040	76.8	82	3.310	1.623

Overall odds ratio adjusted for blocks 24 - 27 (95% LRCI) 0.915 (0.699 - 1.197)

Test HO: odds ratio = 1 (no treatment effect), $P = 0.5172$

Appendix T. Overall estimates of subyearling Chinook salmon spill passage efficiency (SPE) during the two spill treatments by block and logistic regression results comparing the treatments, 11 July through 27 July 2002. 12 h= 0% spill during day and 60% spill during the night. 24 h= 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	SPE	*N*	Odds	SPE	*N*	Odds	Odds Ratio
24	35.6	191	0.553	58.4	154	1.404	2.540
25	58.0	88	1.381	61.6	172	1.604	1.162
26	39.3	145	0.647	51.5	163	1.062	1.640
27	42.1	76	0.727	61.0	82	1.564	2.151

Overall odds ratio adjusted for blocks 24 - 27 (95% LRCI) 1.827 (1.428 - 2.341)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix U. Overall estimates of subyearling Chinook salmon bypass passage efficiency (JBYPE) during the two spill treatments by block and logistic regression results comparing the treatments, 11 July through 27 July 2002. 12 h= 0% spill during day and 60% spill during the night. 24 h= 30% spill during the day and 30% spill during the night. *N* = sample size.

	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
24	36.1	191	0.565	12.3	154	0.140	0.248
25	22.7	88	0.294	9.3	172	0.103	0.349
26	29.7	145	0.422	14.7	163	0.172	0.408
27	25.0	76	0.333	15.9	82	0.189	0.567

Overall odds ratio adjusted for blocks 24 - 27 (95% LRCI) 0.353 (0.256 - 0.482)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix V. Subyearling Chinook salmon spillway (SP), turbines (TU), and juvenile fish bypass (JBS) passage counts by block, treatment, date and diel at John Day Dam, summer 2002.

Species	Block	Trt	Date	Diel	SP	TU	JBS
CH0	24	12 h	7/11/02	Day	0	11	18
CH0	24	12 h	7/11/02	Night	16	5	6
CH0	24	12 h	7/12/02	Day	0	24	28
CH0	24	12 h	7/12/02	Night	40	10	14
CH0	24	12 h	7/13/02	Night	12	3	2
CH0	24	24 h	7/13/02	Day	19	2	3
CH0	24	24 h	7/13/02	Night	16	11	1
CH0	24	24 h	7/14/02	Day	20	8	4
CH0	24	24 h	7/14/02	Night	20	15	7
CH0	24	24 h	7/15/02	Day	4	1	2
CH0	24	24 h	7/15/02	Night	11	7	0
CH0	25	12 h	7/15/02	Day	0	5	3
CH0	25	12 h	7/15/02	Night	12	2	1
CH0	25	12 h	7/16/02	Day	0	4	10
CH0	25	12 h	7/16/02	Night	20	5	5
CH0	25	12 h	7/17/02	Night	19	1	1
CH0	25	24 h	7/17/02	Day	36	7	3
CH0	25	24 h	7/17/02	Night	18	8	2
CH0	25	24 h	7/18/02	Day	20	9	6
CH0	25	24 h	7/18/02	Night	23	16	2
CH0	25	24 h	7/19/02	Night	9	8	2
CH0	26	24 h	7/19/02	Day	30	10	3
CH0	26	24 h	7/19/02	Night	5	12	2
CH0	26	24 h	7/20/02	Day	26	7	8
CH0	26	24 h	7/20/02	Night	18	16	5
CH0	26	12 h	7/21/02	Day	0	14	12
CH0	26	12 h	7/21/02	Night	10	6	1
CH0	26	24 h	7/21/02	Night	5	8	4
CH0	26	12 h	7/22/02	Day	0	12	22
CH0	26	12 h	7/22/02	Night	32	11	5
CH0	26	12 h	7/23/02	Night	15	1	2
CH0	27	12 h	7/23/02	Day	0	8	8
CH0	27	12 h	7/23/02	Night	8	1	0
CH0	27	12 h	7/24/02	Day	0	12	9
CH0	27	12 h	7/24/02	Night	15	3	2
CH0	27	12 h	7/25/02	Night	9	0	0
CH0	27	24 h	7/25/02	Day	6	7	4
CH0	27	24 h	7/25/02	Night	4	2	1
CH0	27	24 h	7/26/02	Day	29	5	3
CH0	27	24 h	7/26/02	Night	9	2	2
CH0	27	24 h	7/27/02	Night	2	2	3

Appendix W. Diel estimates of subyearling Chinook salmon fish passage efficiency (FPE) during the two spill treatments by block and logistic regression results comparing the treatments, 11 July through 27 July 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Day

	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
24	56.6	83	1.304	82.8	64	4.814	3.692
25	59.1	22	1.445	79.5	83	3.878	2.684
26	56.5	62	1.299	79.1	86	3.785	2.914
27	44.7	38	0.808	76.4	55	3.237	4.006

Diel odds ratio adjusted for blocks 24-27 (95% LRCI) 3.292 (2.187 - 5.000)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Night

	12 h			24 h			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	Odds Ratio
24	83.3	108	4.988	62.2	90	1.646	0.330
25	87.9	66	7.264	62.9	89	1.695	0.233
26	78.3	83	3.608	51.9	77	1.079	0.299
27	89.5	38	8.524	77.8	27	3.505	0.411

Diel odds ratio adjusted for blocks 24-27 (95% LRCI) 0.301 (0.201 - 0.444)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Appendix X. Diel estimates of subyearling Chinook salmon spill passage efficiency (SPE) during the two spill treatments by block and logistic regression results comparing the treatments, 11 July through 27 July 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Night							
		12 h			24 h		Observed
Block	SPE	*N*	Odds	SPE	*N*	Odds	Odds Ratio
24	63.0	108	1.703	52.2	90	1.092	0.641
25	77.3	66	3.405	56.2	89	1.283	0.377
26	98.7	83	75.923	36.4	77	0.572	0.008
27	84.2	38	5.329	55.6	27	1.252	0.235
Diel odds ratio adjusted for blocks 24-27 (95% LRCI)				0.394 (0.278 - 0.557)			
Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$							

Appendix Y. Diel estimates of subyearling Chinook salmon bypass passage efficiency (JBYPE) during the two spill treatments by block and logistic regression results comparing the treatments, 11 July through 27 July 2002. 12 h = 0% spill during day and 60% spill during the night. 24 h = 30% spill during the day and 30% spill during the night. *N* = sample size.

Day

	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
24	56.6	83	1.304	15.6	64	0.185	0.142
25	59.1	22	1.445	12.0	83	0.136	0.094
26	56.5	62	1.299	14.0	86	0.163	0.125
27	44.7	38	0.808	12.7	55	0.145	0.179

Diel odds ratio adjusted for blocks 6 - 12 (95% LRCI) 0.133 (0.084 - 0.206)

Test HO: odds ratio = 1 (no treatment effect), $P < 0.0001$

Night

	12 h			24 h			Observed
Block	JBYPE	*N*	Odds	JBYPE	*N*	Odds	Odds Ratio
24	20.4	108	0.256	10.0	90	0.111	0.434
25	10.6	66	0.119	6.7	89	0.072	0.605
26	9.6	83	0.106	15.6	77	0.185	1.745
27	5.3	38	0.056	22.2	27	0.283	5.054

Diel odds ratio adjusted for blocks 24-27 (95% LRCI) 0.907 (0.354 - 2.286)

Test HO: odds ratio = 1 (no treatment effect), $P = 0.8359$